TM 1-416

WAR DEPARTMENT TECHNICAL MANUAL

MISCELLANEOUS AIRCRAFT EQUIPMENT

WAR DEPARTMENT • 22 MARCH 1944

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[A. G. 300.7 (11 Feb 44).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:
Bn and H 1 (6).
(For explanation of symbols see FM 21–6.)

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TECHNICAL MANUAL

MISCELLANEOUS AIRCRAFT EQUIPMENT

CHANGES No. 1

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TM 1–416, 22 March 1944, is changed as follows:

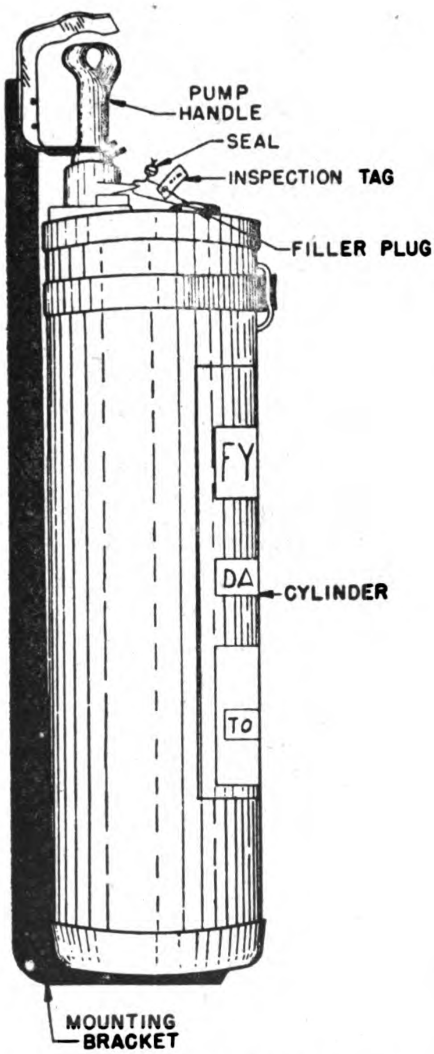

Figure 12. Carbon-tetrachloride hand-type fire extinguisher.

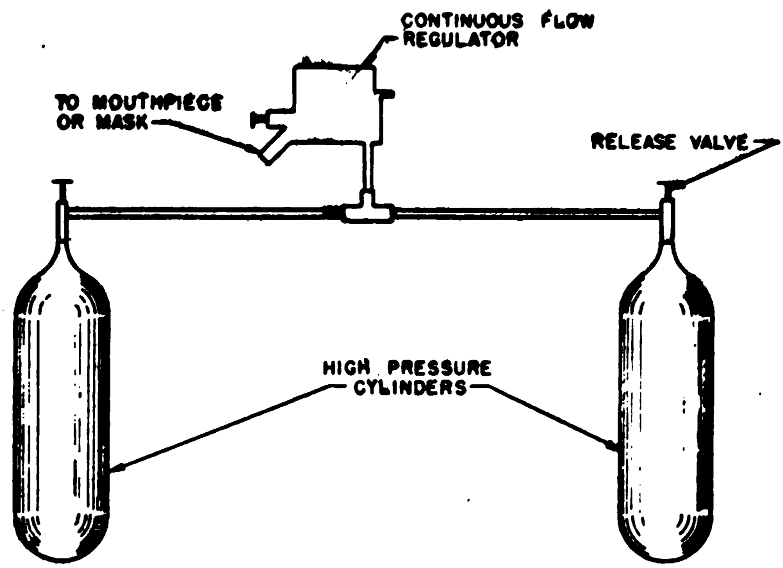

Figure 43. High-pressure continuous-flow oxygen system.

[A. G. 300.7 (21 Jun 44).]

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SECTION I
GENERAL

1. PURPOSE OF MANUAL. The purpose of this manual is to present in one place and in compact form general information on miscellaneous aircraft equipment. The information given is, of necessity, not as detailed as that given in Technical Orders on the equipment. Whenever detailed information on an item of equipment is desired the applicable Technical Orders should be consulted.

SECTION II
FLOTATION EQUIPMENT

2. GENERAL. a. Purpose. Flotation equipment is designed primarily for the use of the crew of an airplane in the event of a forced landing during an overwater flight. It is extremely important that this equipment be kept in perfect condition at all times.

b. Types. In general, flotation equipment may be divided into two types: one type, designed for the use of the crew, includes life rafts and life vests; the other type is designed to provide for the flotation of the entire aircraft.

c. Means of inflation. Carbon dioxide (CO_2) gas is used to inflate all flotation equipment because it liquefies at a relatively low pressure and large amounts can be stored in small cylinders. The fact that it is neither inflammable nor poisonous adds to its desirability as a means of inflation.

3. CO_2 CYLINDERS AND RELEASE VALVES. a. Cylinders. The cylinders used for the storage of CO_2 gas vary greatly in size. They are of

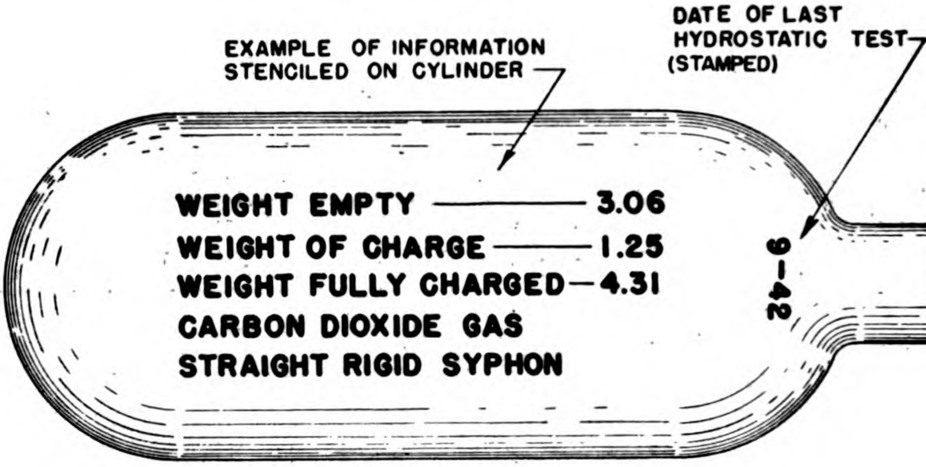

Figure 1. Typical CO_2 cylinder for aircraft use.

seamless steel construction and have rounded bases. As they are thin-walled, they should be handled carefully. These cylinders are painted with aluminum, gray, or blue paint. All except those used with life vests have certain information stenciled on them. Figure 1 shows a typical CO_2 cylinder for aircraft use.

b. Release valves. Release valves for CO_2 cylinders may be divided into three general types: The hand shut-off type, the quick-release type, and the cutter type.

(1) The hand shut-off valve is very similar in construction and operation to a simple water faucet. (See fig. 2.) When the hand wheel is turned

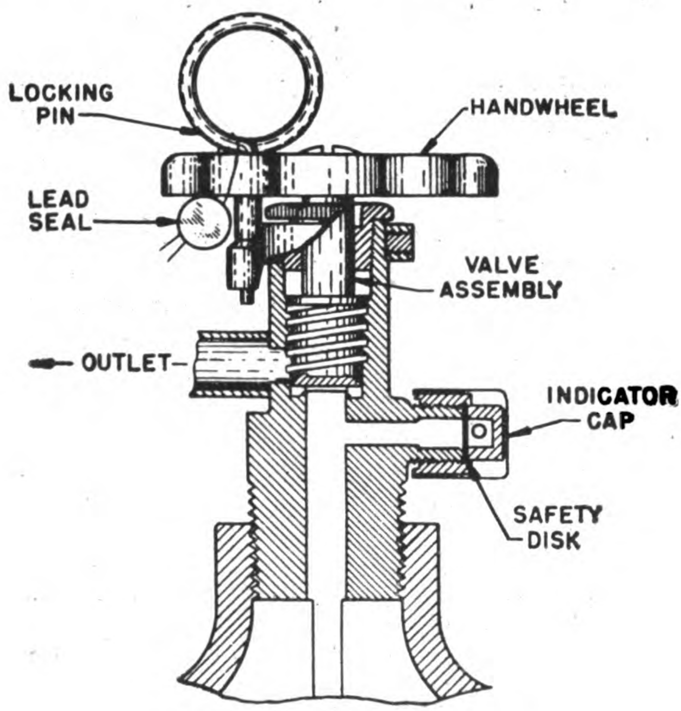

Figure 2. Hand shut-off valve.

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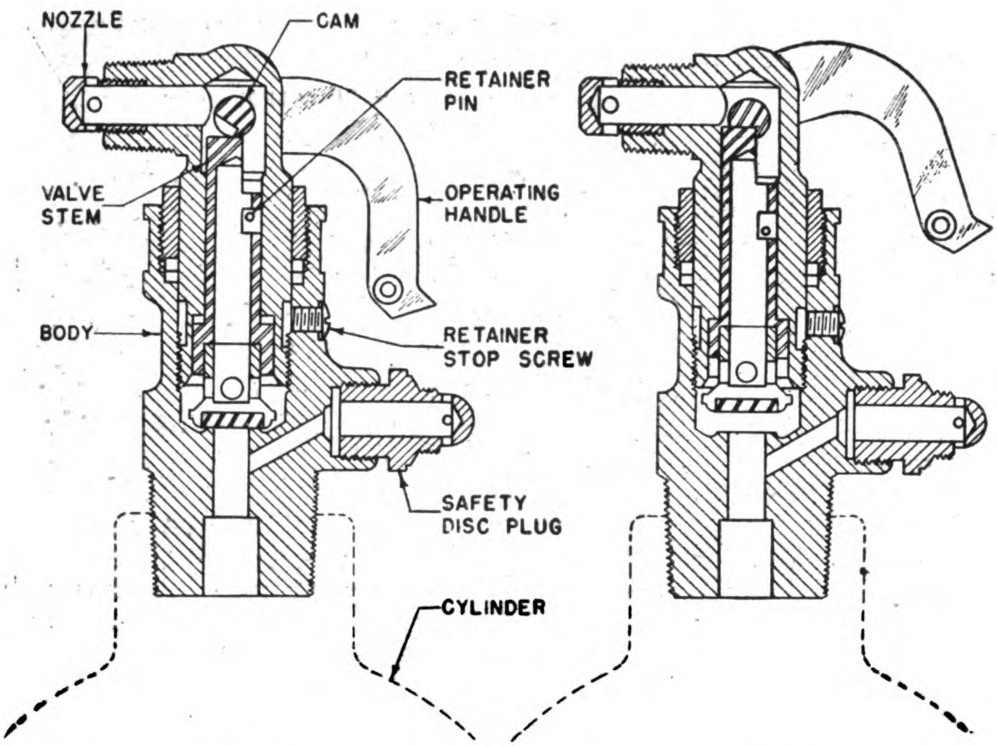


① *Closed.* ② *Open.*

Figure 3. Quick-release type valve.

in a counterclockwise direction, the valve is opened and the gas can escape. When the wheel is turned in the opposite direction, the valve is closed.

(2) A quick-release valve consists essentially of a single-seat piston type valve which may be operated by a release cord or cable. Figure 3 shows one type of quick-release valve which employs a cam to hold the valve stem on its seat. When the release cord is pulled, the cam is rotated to the position shown in figure 3② and the pressure of the gas will unseat the valve. The gas then flows through the holes in the lower end of the valve stem, through the hollow valve stem, and out of the nozzle. Figure 4 illustrates another kind of quick-release valve which is sometimes called an "explosion" type. The stem is held on the seat by the top or yoke. The top is locked down by the locking link and the trigger handle. A pull on the release cord moves the trigger handle past the dead-center position and unlocks the top. The gas then moves the stem up and escapes through the outlet.

(3) The valve shown in figure 5 is called a cutter type valve. It consists essentially of a hollow cutter, a spring, and a mechanism for tripping the valve. When the release cable is pulled or pressure is applied to the diaphragm, the release mechanism disengages and allows the spring to move the cutter downward and puncture the sealing disk. The CO_2 will then flow through the hollow poppet to the outlet. The indicator cap provides a means of determining whether or not the cylinder has been discharged.

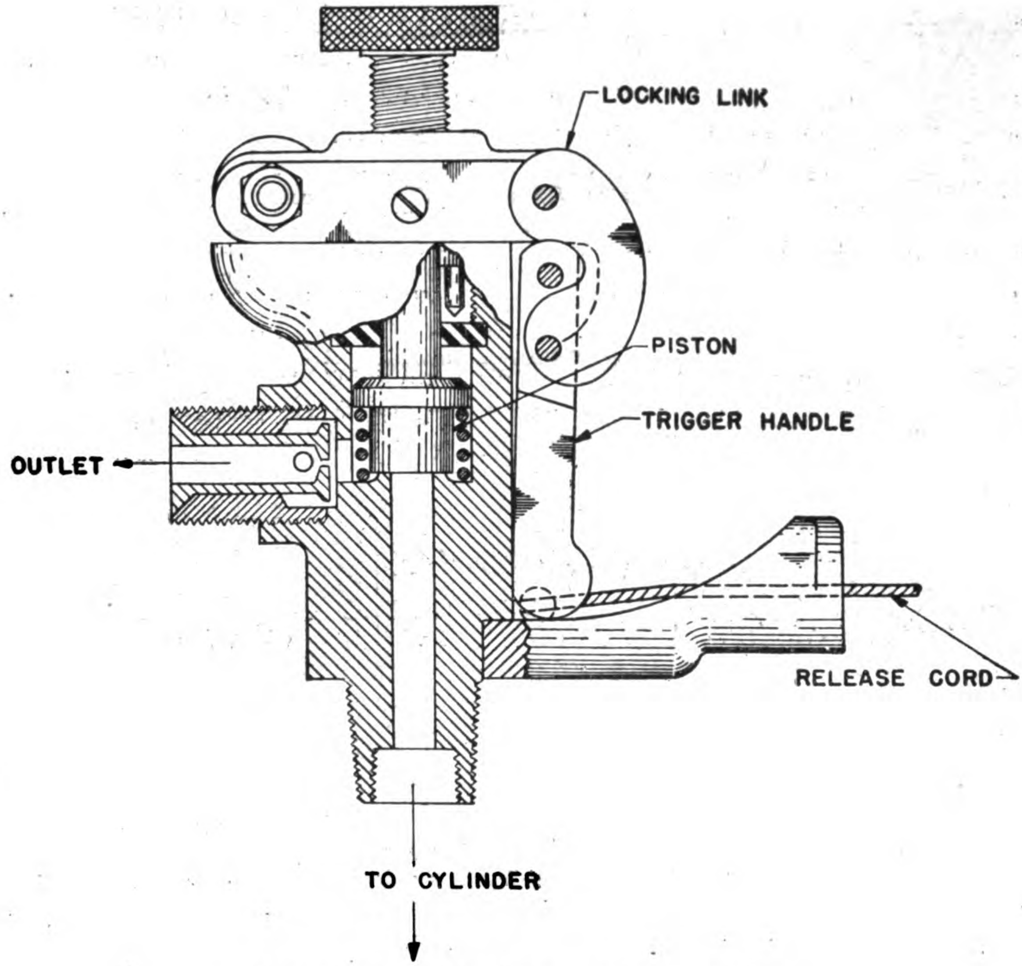


Figure 4. Explosion type quick-release valve.

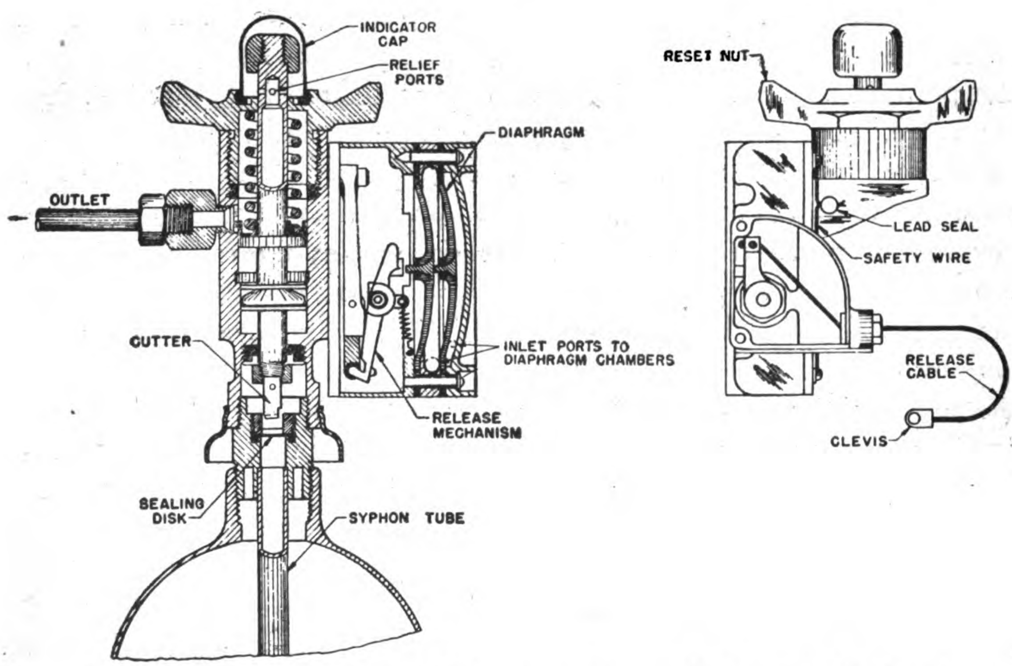


Figure 5. Cutter type valve with pressure-operated release mechanism.

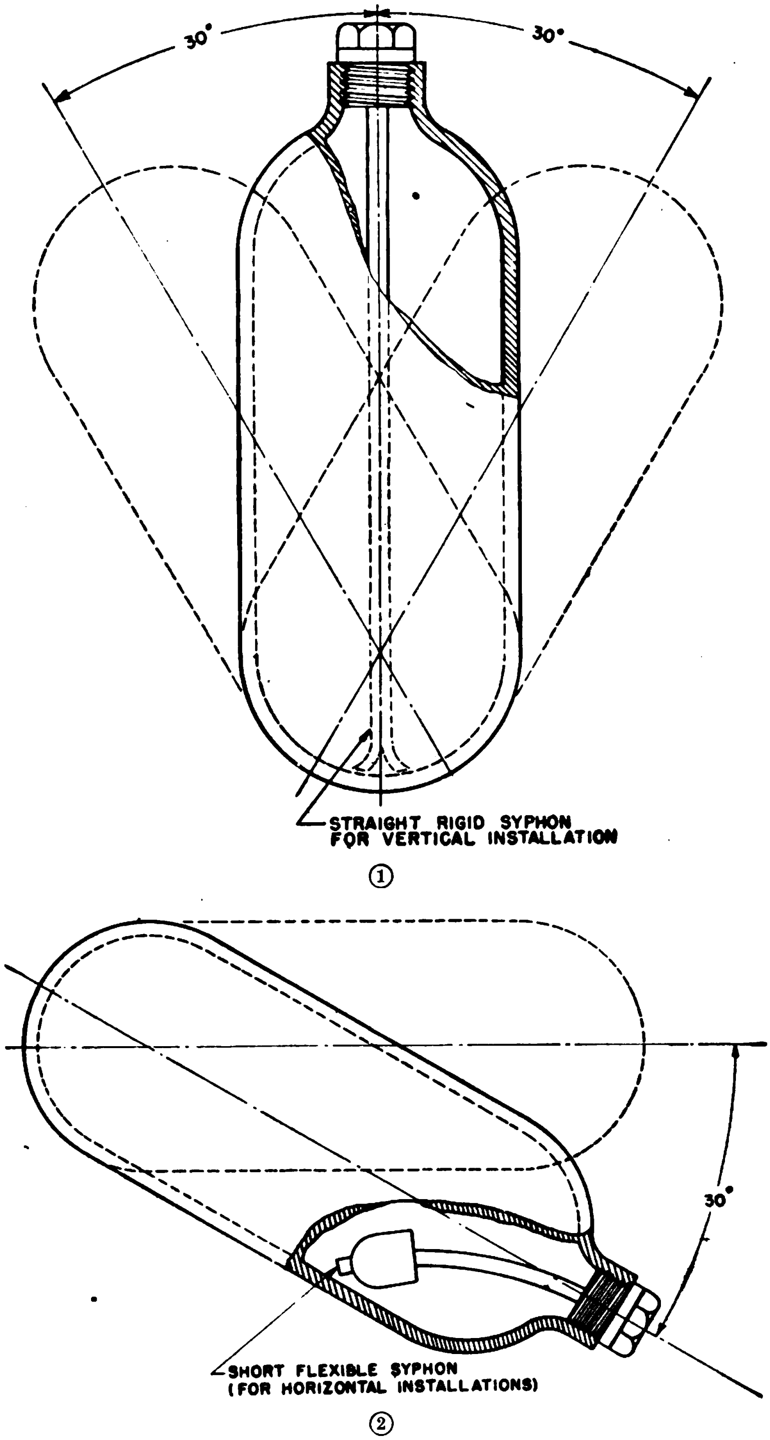


Figure 6. Mounting positions of CO_2 cylinders.

c. Gas storage. (1) CO_2 is stored at pressures ranging from 700 to 1,000 pounds per square inch. Under these conditions, about two-thirds or three-fourths of the CO_2 will be in a liquid state.

(2) The capacity of a CO_2 cylinder is determined by the weight of gas it will hold at normal storage pressure. The amount in pounds of gas stored in a cylinder is stenciled on the side of the cylinder.

(3) Some types of CO_2 cylinder valves are equipped with safety disks which are designed to rupture and discharge the cylinder if the pressure exceeds 2,700 to 3,000 pounds per square inch. This is necessary to prevent harm to the cylinders if the pressure of the gas increases because of increased temperature. In some fire-extinguisher installations, a flexible tube is connected to the valve outlet (fig. 3) in which the safety disk is installed. The other end of this tube is connected to a fitting which is mounted in the airplane skin. This fitting contains an inspection disk. The sealing disk of cylinders equipped with cutter type valves functions as a safety disk.

d. Siphon tubes. (1) When CO_2 changes from a liquid to a gas, its temperature may drop as low as $-110°$ F. At this temperature it freezes and forms carbonic snow. To prevent this snow from being formed in the release valve (which would stop or slow up the gas flow), a siphon tube is installed in each cylinder except those used with life vests. When the release valve is opened, the gas forces the liquid through the siphon tube and out the nozzle. The liquid changes to a gas as it leaves the nozzle.

(2) Because of the different mounting positions of the cylinders, two types of siphon tubes are used. A weighted, short, flexible siphon is used for horizontal installations and a straight, rigid siphon for vertical installations. Figure 6 illustrates each type of siphon tube and shows the mounting positions of the cylinders. The type of siphon tube installed in the cylinder is marked on the valve or bushing—"S" indicating straight rigid and "SF" indicating short flexible.

e. Inspection and maintenance. (1) Prior to the first flight each day, the cylinder is visually checked for evidence of discharge. This check is made by checking the safety wire on the valve and noting whether or not the indicator cap (cutter type valves) or the indicator disk is still in place. Proper mounting position, security of mounting, and general condition of the cylinder should be checked daily. At the first 50-hour inspection after installation, and every 6 months, the cylinder is removed from the airplane and checked by weighing. Once every 5 years the cylinder must be subjected to a pressure check known as a "hydrostatic" test. The date of the last hydrostatic test is checked at the time of each 6-month weight check. This date is stamped on the upper shoulder of the cylinder. CO_2 cylinders are removed and turned in if the hydrostatic test is due within 6 months. The life-vest cylinder requires no weight check or hydrostatic test.

(2) Maintenance of CO_2 cylinders consists of merely keeping them painted to prevent rusting. Aluminum, gray, or blue paint is used for this purpose.

4. PNEUMATIC LIFE RAFTS. a. Types. Seven types of pneumatic life rafts used by the Army Air Forces at the present time are—

(1) Type A–2 (1,000-pound capacity).

(2) Type A–3 (1,000-pound capacity).

(3) Type B–3 (500-pound capacity). This type is being replaced with newer types.

(4) Type B–4 (500-pound capacity). This type is being replaced with newer types.

(5) Type AN–R–2A (250-pound capacity). This is a one-man parachute type raft.

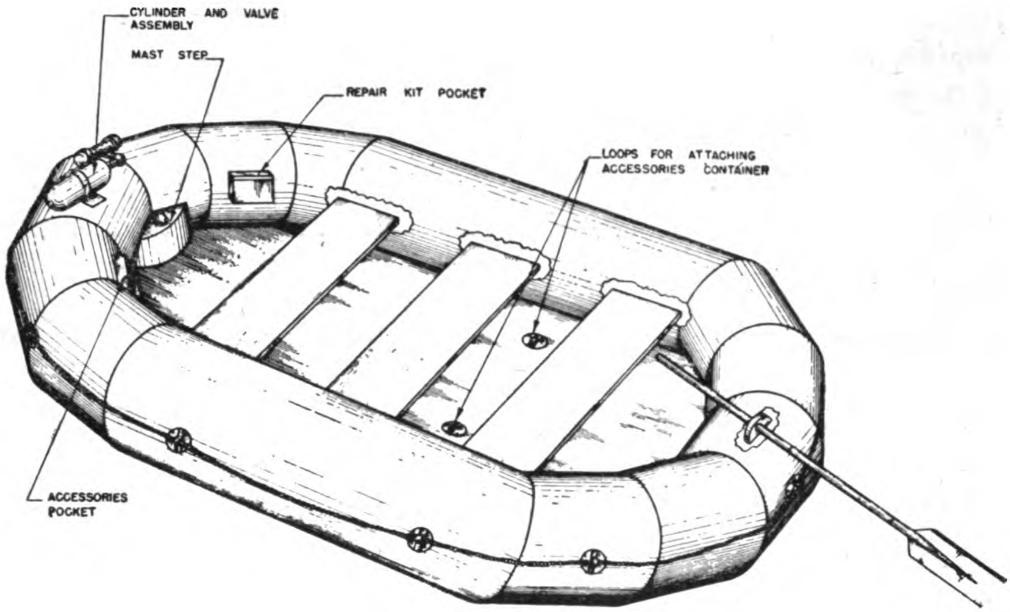
(6) Type E–1 (2,500-pound capacity).

(7) Type E–2 (2,500-pound capacity).

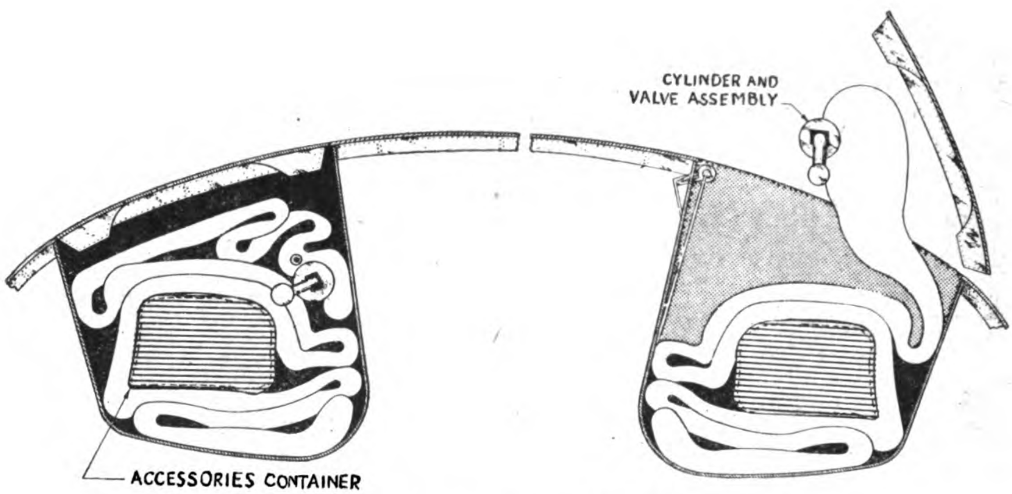
b. Description. Types A–2 and B–3 are of an earlier design. They consist of an outer covering of rubberized fabric and two removable "latex" rubber bladders. These bladders are provided with valves and connections for CO_2 inflation. Types A–3, B–4, E–1, and E–2 are later models constructed entirely of rubberized fabric in the form of boat-shaped tubes equipped with valves and manifolding for CO_2 inflation. Each cell of these types is equipped with a topping-off valve. The type E–1 is a drop type raft which is used for rescue work and is not classed as standard equipment for use by crews of airplanes on overwater flights. The one-man parachute type raft is discussed later in this section. Figure 7① illustrates a typical life raft.

c. Accessories. The following accessories are kept in each A–2, A–3, and E–2 raft carried in an airplane: one carrying kit for the raft (except in aircraft provided with a special raft compartment), three oars, one hand pump (complete with hose), one repair kit, one bailing bucket, one bullet-hole repair plug, 40 feet of 75-pound lashing cord, one charged CO_2 cylinder with release type valve (to be connected to the raft in readiness for operation at all times), one emergency signal kit, one sea anchor, seven cans of emergency drinking water, three fluorescein-dye sea markers, nine packages of emergency subsistence rations, a floating identification flashlight and battery, one compass, one scout knife, one police whistle, one first aid kit, one emergency signaling mirror, four tubes of sun-protecting ointment, one cloth for shade and camouflage, one cloth to be used for catching water or as a sail, one fishing kit, and one accessories container. A life line and two righting ropes are attached to the raft. The knife, whistle, lashing cord, bailing bucket, and repair kit are kept in the accessories pockets of the raft. All other accessories except the oars are placed in the central accessories container. The oars will be stowed on the side of this container with the ends inserted in the pocket flap. The accessories included with the E–1 type raft are four oars, one CO_2 cylinder and valve, one pump complete with hose, one bailing bucket, one repair kit, one sea anchor, two pieces of cloth, one emergency signaling mirror, one central accessories container, and 40 feet of 75-pound lashing cord.

(1) After the accessories have been placed in the container the kit is rolled and tied with the tying tapes. If tapes are not provided the kit will be securely tied at each end and in the middle with 75-pound cord. If loops



① *Inflated.*



② *One method of stowage for automatic inflation and ejection.*

Figure 7. Pneumatic life raft.

are provided on the floor of the raft, the kit will be securely tied to them. If loops are not provided, the kit will be tied to the oar locks.

(2) If the life-raft compartment is large enough, all accessories are stowed in the raft. If the compartment is not large enough to accommodate the raft and the accessories kit, the kit may be removed and stowed in a location which will make it easily accessible in case of an emergency water landing. However, the fishing kit, oars, and pump must be kept in the raft at all times.

(3) The emergency signal kit is filled each time the raft is placed in the airplane. It contains one pyrotechnic pistol and five red parachute dis-

tress signals. After these items are placed in the signal-kit container, two coats of rubber cement are used to cement down the folds of the bag. A sealing strip is then cemented over the opening edge with two coats of rubber cement. If the raft is removed from the airplane for storage, the items in the emergency signal kit are removed from the raft and returned to their proper place of storage.

d. Stowage. There are three basic ways of carrying life rafts in an airplane. The first is to leave the raft in the carrying case and lash it to some structural member of the airplane; the second is to remove it from the carrying case and stow it in a container provided in the airplane; and the third is to remove it from its carrying case and pack it in a compartment from which it can be ejected automatically. (See fig. 7②.)

e. Operation. (1) INFLATION. The life raft is removed from the carrying case or container and unfolded to at least one-half its length. The raft is inflated by grasping the ball handle and pulling the valve release cord with a jerk. This opens the release valve, allowing the gas to fill the raft. The specified charges in cylinders for rafts are such as to inflate the rafts to a pressure of 1 pound per square inch at 70° F. The initial pressure is low because of the low temperature of the carbon dioxide, but the pressure will increase until atmospheric temperature is reached, usually in 5 to 10 minutes. If the gas cells appear too tightly inflated at any time, the pressure can be relieved by opening the topping-off valves. As soon as the pressure is sufficiently reduced, the valve should be securely closed. At all times the pressure should be just sufficient to maintain a well-rounded contour of the cells. If a cell is underflated, either initially or because of gas leakage, the hand pump can be used to increase the pressure by pumping air through the topping-off valve. Some rafts are equipped with seats which may be inflated with the hand pump through valves located on the side or bottom of the seats.

(2) AUTOMATIC INFLATION AND EJECTION. For installation on airplanes equipped for automatic inflation and ejection, the raft is removed from the carrying case before it is stowed in the airplane raft compartment. The raft should be *folded* (accordion fashion) and not rolled. (See fig. 7②.) In some installations, a cable from the cabin inside the airplane is attached to the raft-compartment door latch and to the loop on the end of the valve-release cord. A pull on this control cable first releases the raft-compartment door latch and then releases the CO_2 by pulling the valve-release cord. The inflation of the raft causes its ejection from the compartment. A static line is sometimes provided to prevent the raft from floating away from the airplane. This line should be disconnected from the airplane immediately after the airplane strikes the water. In other installations, the static line is attached to the release cord. When

the raft is ejected from its compartment by bungee cords or springs, the static line actuates the valve and inflates the raft.

(3) DEFLATION. In order to deflate the life raft, the topping-off valve on each gas cell is unscrewed and each seat valve is opened. The raft is then folded and rolled toward the valve end to expel all gas. Before the raft is replaced in its carrying case, container, or compartment, it must be completely deflated, the discharged CO_2 cylinder replaced with a charged one, and all valves securely closed. The raft is then folded, and rolled toward the valve end. This will leave the CO_2 cylinder in such a position that it will be readily accessible for inspection and use. Where practicable, the external surfaces of the rubberized fabric are thoroughly powdered with tire talc before folding. Complete instructions for inflation and deflation are printed in black waterproof ink on a white rubber patch (instruction patch) on the stern of each life raft.

f. Service life. Table I indicates the service life of the various types of rafts. Service life is calculated from the date of manufacture. This date is stenciled in black on each raft. Rafts which exceed the age limit must be replaced.

Table I

Type	Service life
A–3	3½ years
B–4	3 years
A–2	4 years
B–3	4 years
AN–R–2A	3 years
E–1	3 years
E–2	3½ years

g. Inspection and maintenance. (1) Prior to installation, inspect the raft visually for chafing and evidence of deterioration. The CO_2 cylinder is checked by weighing to see that it is fully charged. Check the accessories for completeness and serviceability. This includes an operation check of the flashlight assembly and a check of the expiration date on the flashlight battery. If this date is within 30 days, the battery will be replaced. Check the sealing tape on the signal kit. If this tape is loose, check the pyrotechnic equipment for deterioration, replace any defective items, and reseal kit. Upon completion of this inspection, fill out the inspection record form. This form should indicate the date and place of the inspection and should be signed by the inspector. If the inspection discloses a defect in the raft, it will be tagged with a Reparable Part Tag and returned to the depot.

(2) At the 100-hour inspection, remove the raft from the case and inspect for chafing and leaks. Check the topping-off valves for tightness. Check the accessories to see that all are included and in good condition. Inspect the CO_2 cylinder by weighing at the first 100-hour inspection and each

6-month inspection thereafter. CO_2 cylinders are to be handled carefully when inspected. They are light in weight, with comparatively thin walls, and may be easily damaged or weakened. Check the tag to see that it is intact and that it was properly dated and signed. (Type E–1 rafts are not subject to the 100-hour inspection.)

(3) Every 6 months the raft is removed from its carrying bag or compartment, inflated (by using the CO_2 inflation system), and carefully checked for leaks and other defects of structure, connections, or valves. The accessories (except the signal kit) are inspected as described in paragraph 4g(1). The signal kit should be opened and its contents checked for deterioration. Any defective items will be replaced, after which the kit will be resealed and returned to the accessories container. When necessary, the raft is repaired or replaced. If no replacement CO_2 cylinders are available, the raft may be inflated with compressed air. The date of each 6-month inspection is stenciled in indelible ink, in letters and figures ½ inch high, to the right of the inspection patch as viewed from the end of the raft on which the CO_2 cylinder is mounted; for example, "Insp. 8–6–42."

(4) Steps should be taken to seal the accessories kit and life-raft pockets after each inspection, or after the removal of any accessory items for purpose of storage.

(5) No repairs are made to the rubberized fabric of latex bladders other than the patching of small holes. Such repairs are made by cold-patching, three coats of rubber cement being applied. Large rips, tears, and severely chafed areas are cause for condemnation. Normally, maintenance repairs and inspections requiring inflation tests are performed by the station parachute-repair personnel. Replacement of defective parts may be made when serviceable ones are available from stock.

(6) Rafts that are not in use in aircraft are unfolded and stored away from light in a cool, dry place that is favorable to the storage of rubber articles. If the storing facilities are limited, the rafts are stored in the carrying cases provided.

h. One-man parachute type raft. (1) DESCRIPTION. This raft is designed primarily for use in one-, two-, and three-place airplanes engaged in overwater flight, but is also the equipment of each member of medium and heavy bombardment airplanes engaged in overwater flight. A life vest must be used with this type of raft, as the user must be kept afloat until the raft can be removed from the parachute harness and taken out of its container. The raft is encased in a seat pack for attachment to parachute harness in place of the parachute seat cushion. The pack consists of a rectangular-shaped fabric cover sufficient in size to store the deflated raft and accessories. Essentially, the parachute type raft consists of two-ply rubberized fabric in the form of a boat-shaped inflatable tube equipped with a CO_2 cylinder and a hand shut-off valve. (See fig.

8.) Inflation is accomplished by unscrewing the cylinder-valve hand wheel, which is normally locked by a pin. The following accessories are provided in the seat pack: two paddles, one rubber tube for mouth inflation, one repair kit, four bullet-hole plugs, one bailing bucket, one sea anchor, one seat pack, one sea marker, and one can of drinking water.

(2) OPERATION IN WATER. The life vest is inflated *before* the water is entered. The parachute harness is released in the normal way after the

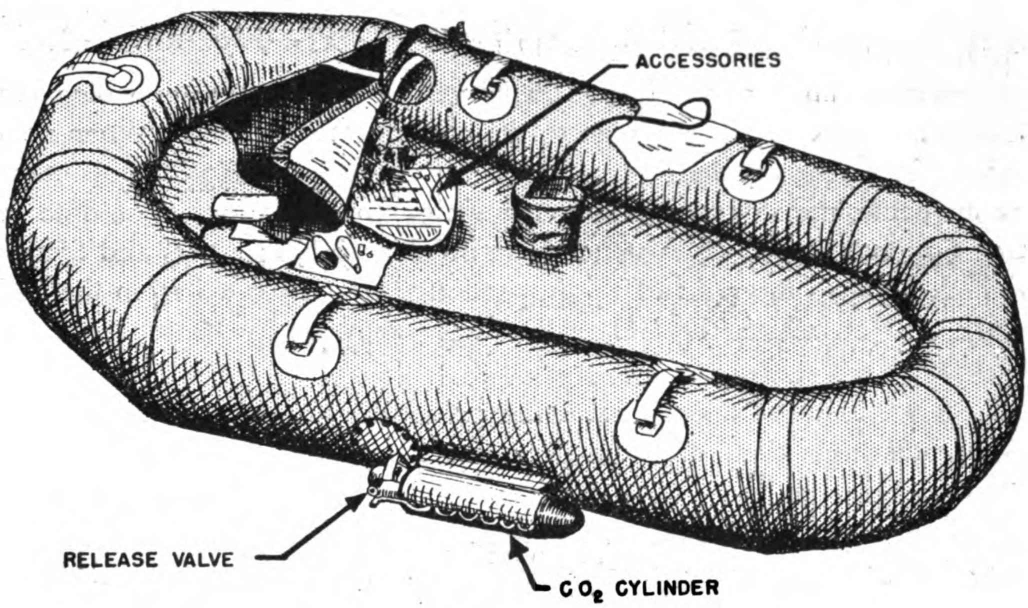


Figure 8. One-man parachute type raft.

water has been entered, and the raft is recovered from the parachute harness by means of a strap. The raft pack is opened, and the raft is inflated by operating the release valve. The raft is entered at the narrow end by grasping the loop handles on top of the raft and pulling the body forward. Stoppers are provided in the raft pocket to plug up any small holes. If further inflation is necessary, the mouth inflation tube is attached to the topping-off valve, the valve is opened two full turns, and the raft is inflated by blowing into the tube. The valve is then closed and the tube may or may not be removed. The sea anchor should be thrown out to retard drift.

(3) INSPECTION AND MAINTENANCE. Prior to the first flight each day that the raft is to be used the pack is examined for acid contamination, the union nut is checked for tightness, and the locking pin is checked for easy removal. The semimonthly inspection is performed by the parachute repair section. The date of this inspection is stenciled on a tag attached to the raft. When not in use, the raft is stored away from light in a favorable place. Only small repairs are made to the rubberized fabric; large rips, tears, and chafed areas are cause for condemnation. These rafts are

considered unserviceable 3 years after the date of manufacture and must then be replaced.

5. PNEUMATIC LIFE VESTS. a. Description. Two types of pneumatic life-preserver vests in general use are the B–3 and the B–4. The type B–3 life-preserver vest (fig. 9) consists of a double-compartment, cotton-fabric casing enclosing two separate latex rubber cells. The type B–4 vest consists of two compartments constructed from rubberized fabric. Mouth valves are installed in both cells of these vests. Rubber tubes are attached

Figure 9. Pneumatic life-preserver vest.

to the valves. These vests are inflated with CO_2 gas supplied by two small CO_2 cylinders, one for each compartment. A sea marker packet is cemented on the left side between the compartments. Vests are worn deflated under the parachute harness, and should never be worn under tight-fitting clothing.

b. Operation. The vest is inflated by pulling downward on the cords, which are attached to two discharge levers. This pull actuates both plungers which in turn puncture the sealing disks on the two CO_2 cylinders. Sometimes an additional pull on the cords is necessary before both sealing disks are punctured. When additional inflation is necessary, the mouth

valves at the neck of the vest are opened and air is blown into the vest through the tubes. The dye in the marker packet may be released by pulling down on the tab. When the CO_2 cylinders are placed in their compartments the ends which contain the sealing caps are inserted first. The discharge lever must be parallel to the side of the container and safetied in this position with light safety wire. This will prevent premature discharge of the cylinder when the container cap is being secured in place. The container cap should always be tightened firmly by hand to prevent leakage. Deflation is accomplished by opening the mouth valves and slowly rolling up the vest.

c. Service life. Type B–3 vests are considered unserviceable 5 years after the date of manufacture. Type B–4 vests are considered unserviceable 3 years after the date of manufacture. This date is stenciled on each vest. CO_2 cylinders that are removed from condemned life vests are returned to stock.

d. Inspection and maintenance. When not in use, the pneumatic vest is kept in its original container and stored in a cool, dry storage room. The vests are inspected prior to the first flight each day by inflating with air and visually checking for leaks. The sealing cap is checked to see that it has not been punctured. Each 6 months the vest is checked for leaks by inflating it with CO_2 and submerging it in water. The date of each 6-month inspection is stenciled in indelible ink on the vest; for example, "Insp. 6–23–42." Leaks and punctures in the type B–3 vest are repaired by removing the stitching of the fabric outer casing near the leak and then applying standard Army Air Forces cold patch to the rubber cell. The cell is then tested for leakage by inflating and submerging it in water. Snagged or chafed spots in the outer casing fabric are repaired by sewing a patch of 6-ounce cotton fabric over the damaged area, provided the patch does not exceed 2 square inches in area. Leaks and punctures in the rubberized fabric of the B–4 vest are repaired by applying a standard cold patch. Repairs and the performance of semiannual inspections will normally be performed by station parachute-repair personnel.

6. AUTOMATIC FLOTATION EQUIPMENT. a. General. Automatic flotation gear is essentially a safety device which provides an automatic means of floating a land airplane which makes a forced landing on a body of water. In general, it consists of a CO_2 cylinder equipped with a cutter type valve, flotation bags, actuators, and a manual release handle. (See fig. 10.) There are two actuators so located that the system will function regardless of the landing position of the airplane. Two piston-bag release cylinders are included to open the bag compartment doors.

b. Operation. In cases of a forced landing on water, the flotation-bag containers are automatically opened and the bags inflated when either of the actuators has been submerged to a depth of approximately 14 to 32 inches. When the actuator is submerged to this depth, the air trapped

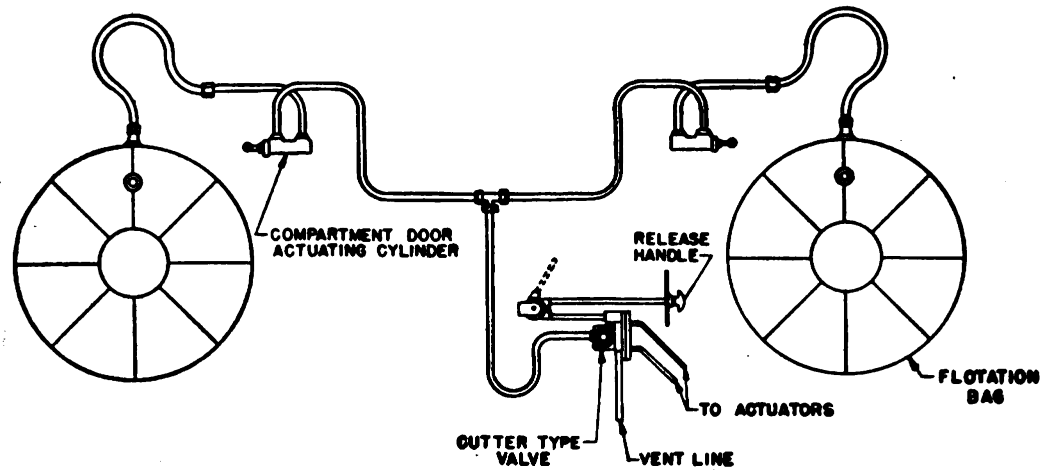


Figure 10. Schematic drawing of an automatic flotation system.

in it operates the cutter type release valve by exerting a pressure on the diaphragm. (See fig. 5.) If the automatic valve fails to function, the system may be operated by pulling the manual release handle. The release handle should not be pulled until the airplane has come to rest on the water; otherwise the bags may be torn or badly damaged.

c. Stowage of bags. It is imperative that flotation bags be completely deflated when they are packed in their compartments. The preferred method is to use suction to evacuate the bags. Unless the bags are completely deflated the gas remaining in them will expand sufficiently to force the cover off the container boxes when the airplane is flying at high altitudes. When the bags are stowed in their compartments, the connections to each bag must be tight and the deflation valves tightly closed. The bags are so placed in the containers as to avoid sharp bends in the flexible hose.

d. Inspection and maintenance. Prior to the first flight each day, check the cylinder for premature discharge and the container covers for tightness. On the 50-hour inspection, check all accessible fittings for tightness and all tubing for visible damage. The CO_2 cylinder used for automatic flotation equipment receives the same inspection as that used with the life raft. Every 6 months an operation check of the gear is made. Defective parts are repaired or replaced. The date of this inspection is stenciled on the container cover. Maintenance procedures are similar to those for pneumatic rafts. When flotation bags are to be out of service for more than 1 month, they should be partially inflated and hung in a cool, dry, dark place. All open ends of tubing, etc., are closed with suitable plugs which are removed when the bags are reinstalled in the airplane. Rubberized-fabric flotation bags, in use or in storage, will be disposed of as unserviceable 3 years after the date of manufacture. The date of manufacture is stenciled on each rubberized bag.

SECTION III
PORTABLE FIRE EXTINGUISHERS

7. GENERAL. Two general types of fire-extinguishing equipment are used in aircraft: the fixed type, built into airplanes and employing carbon dioxide; and the portable type, employing either carbon dioxide or carbon tetrachloride. Only the portable types are discussed in this section. A carbon-dioxide extinguisher is shown in figure 11 and a carbon-tetrachloride extinguisher in figure 12.

8. CARBON-DIOXIDE PORTABLE EXTINGUISHERS. a. Description. (1) The gas, carbon dioxide, used in this type of extinguisher is heavy and inert. It smothers the flame by keeping from it the oxygen needed to sup-

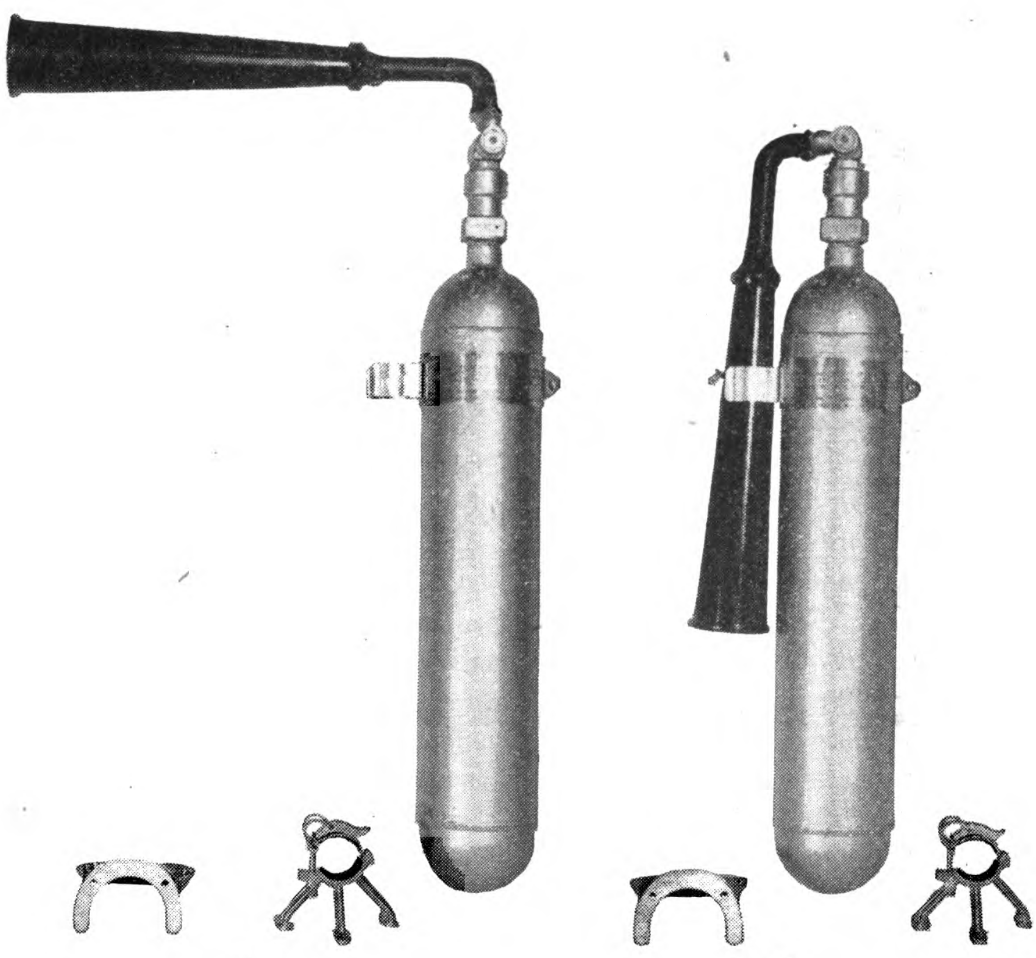


Figure 11. Carbon-dioxide portable fire extinguisher.

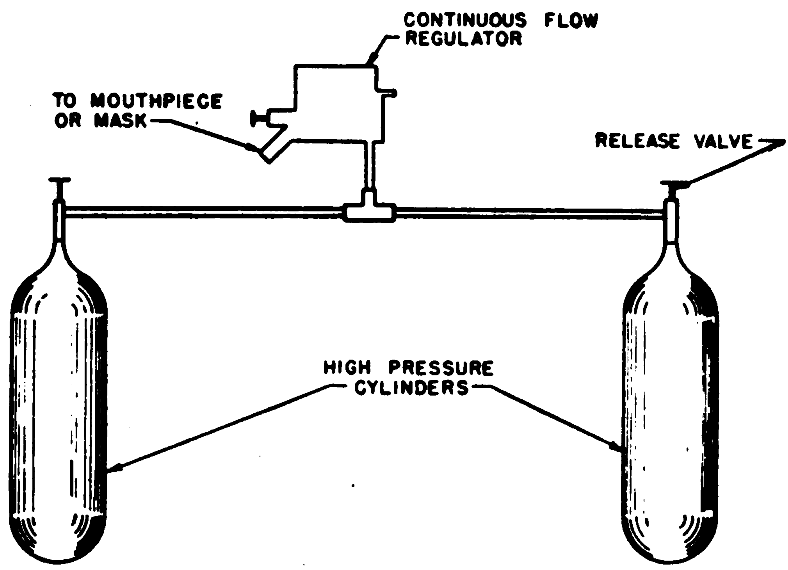


Figure 12. Carbon-tetrachloride hand type fire extinguisher.

port combustion. It is one of the most effective materials for combating gasoline or oil fires and may be used on wood and fabric fires. Since it can be changed readily to a liquid by applying pressure, a sufficient supply to combat small fires can be carried in a small space.

(2) The body of an extinguisher of this type is a steel cylinder capable of sustaining several times the normal storage pressure of 700 to 1,000 pounds per square inch. The construction of this cylinder is identical with those described in section II. The cylinder is equipped with a valve which may be operated quickly and a handle which insures that the extinguisher will be held in the proper position for discharge. Before installation, a flexible hose, a hollow wood insulating handle, and a metal or composition horn—all in one assembled unit—must be attached to the valve. This horn-and-hose assembly is used to direct the CO_2 gas toward the fire.

b. Operation. To discharge the extinguisher, the release valve is opened. In one type of extinguisher (fig. 11) the valve is opened when the horn is pulled away from the bracket. The pressure of the gas forces the liquid CO_2 through the siphon tube to the valve. From there it passes through the hose into the horn, where it immediately changes to a gas. While changing to a gas, the liquid absorbs heat from the horn, greatly reducing its temperature. To prevent the hands from freezing to the horn, the handle (not the horn itself) should be held. The discharged carbon dioxide must be directed as close to the base of the fire as possible, not through the flames. Thus the gas will be concentrated where needed, and the cold gas will help to cool the burning material below its ignition temperature.

c. Installation. The extinguisher is normally mounted in a vertical position. Its location in the airplane depends largely upon the airplane itself.

d. Inspection and maintenance. The following inspections and maintenance must be made on extinguishers.

(1) Check the brackets. They must be installed securely, must hold the extinguisher firmly and yet release it quickly for immediate use.

(2) Check the cylinder. The copper safety wire may have been broken, the valve opened, and the cylinder discharged; or the cylinder may have been overheated and the safety disk ruptured.

(3) Wipe off all dust, grease, or oil. Grease or oil should not be allowed to accumulate on this equipment.

(4) Retouch any injured places in the protective coating with a lacquer similar to that originally used. Corrosion weakens the cylinder.

(5) Each cylinder must be given a weight check at installation, at the first 50-hour inspection after installation, and every 6 months. Once each 5 years the cylinder must be returned to the depot for the hydrostatic test.

(6) Gas pressure increases with an increase of temperature. Since the safety disk may burst from this pressure increase, no charged cylinder of this type should be exposed to temperatures above 130° F. If extinguishers must be kept in places where exposure to the sun may produce such temperatures, proper protective coverings must be provided locally.

9. CARBON-TETRACHLORIDE HAND TYPE EXTINGUISHERS. a. Description. (1) The carbon tetrachloride employed in this type of extinguisher may be used safely on fires involving low-voltage electric current. It is effective in all kinds of weather. It is also effective, either alone or with carbon dioxide, for combating fires in fabric, wood, etc. It is not very satisfactory for gasoline or oil fires, since it is applied in the liquid state and liquids heavier than oil tend to spread such fires.

(2) This extinguisher consists of a brass cylinder with a filler plug in the top and an outlet at the bottom. It is equipped with a hand pump and a check valve and has a capacity of 1 quart. Pressure to discharge the liquid is generated quickly and easily by the hand pump, which, since the pressure is built up, need not be worked continuously. When full and in operating condition, the extinguisher is tagged and the handle is safetied with a soft copper wire 0.020 inch in diameter. A lead-seal hand press is used to apply a lead seal to the safety wire.

b. Operation. The extinguisher is operated by rotating the handle 90°, breaking the safety wire, working the pump, and directing the stream to the base of the fire. The stream of carbon tetrachloride has an effective range of from 20 to 30 feet. Even when cold, this liquid gives off fumes which will make one ill. When in contact with a flame, it gives off poisonous phosgene gas. To prevent fumes from being inhaled, full ventilation must be provided at once if carbon tetrachloride has been used in a closed space.

c. Installation. This type of fire extinguisher may be mounted either horizontally or vertically. When it is mounted vertically, the nozzle or

discharge end is at the bottom. Extinguishers accessible both from within aircraft and from the ground are, whenever possible, located on the side of the aircraft normally approached for entrance. Location markings are painted or stenciled on access doors or on the outside surface of the airplane.

d. Inspection and maintenance. During the daily inspection, the following procedure is followed:

(1) Check the mounting brackets. They must be mounted securely and should hold the extinguisher firmly, yet release it quickly and easily when needed.

(2) Check the extinguisher. A broken safety wire is evidence that it may have been used and may need refilling. Fluid on the outside of the cylinder indicates a leak. See that the hole in the nozzle is not obstructed.

(3) Send the extinguisher to the proper air force unit if refilling or servicing is needed.

(4) Keep the extinguisher free from dust, dirt, and grime. If necessary, use liquid cleaner and polish.

(5) See that the dated inspection tag is properly attached to the safety wire and that the safety wire is not broken.

(6) Each time the extinguisher is filled and once every 12 months an operation test of the pump is made. First, the liquid is pumped into a clean glass container. A milky appearance indicates impure liquid. A brownish color indicates that water has corroded the cylinder. If the pump does not work properly, a few drops of neat's-foot oil should be placed on the piston rod. This will work down to the leather piston cup and keep it soft and in good condition. If the pump shaft is corroded, it should be cleaned with metal polish and then coated with light cup grease. If the liquid is clean, it may be returned to the cylinder. Enough new fluid should be added to fill the cylinder, and the filler cap should be replaced and tightened. The cylinder should then be safetied and sealed and the date stamped on the inspection tag.

10. FIRE-FIGHTING INSTRUCTIONS. a. General. Since extinguishing equipment carried on aircraft is adequate for combating newly started fires only, the extinguishers, regardless of type, should be put into action as soon as possible after the fire starts. In case of an engine fire, shut off the supply of gasoline, fully open the throttle, and open all cooling flaps. To combat cabin fires, close all windows and ventilators and use the extinguisher.

b. Choice of extinguisher. The carbon-dioxide fire extinguisher is paritcularly effective in combating gasoline or oil fires. However, if fabric, wood, etc., are involved, the carbon-tetrachloride extinguisher may be used alone or in conjunction with the carbon-dioxide extinguisher.

c. Precautions in use. (1) Carbon dioxide (CO_2) is a nonpoisonous gas, and breathing it along with fresh air will not harm a human being either at the time it is inhaled or afterward.

(2) Carbon tetrachloride is a volatile fluid, the gas of which is very irritating. Breathing large amounts of this gas is dangerous. In case any odor of carbon tetrachloride is detected during flight, an investigation to determine its source should be made immediately. If it is found that a fire extinguisher is leaking and the leak cannot be stopped, the extinguisher should be discharged overboard.
(3) When sprayed on a fire, carbon tetrachloride produces phosgene. The inhalation of even a small amount under such conditions may produce harmful effects, and, if a sufficient quantity is taken into the lungs, the results may be fatal. Breathing the fumes when this fluid is used on a fire should therefore be avoided.

SECTION IV
FIXED FIRE EXTINGUISHERS

11. GENERAL. The chief purpose of fixed fire extinguishers is to provide a means of extinguishing fires in and around the airplane engines. They may also be used in connection with amphibian hulls, fuel-tank compartments, or other sections of the airplane inaccessible to members of the crew. Because of the many types of fixed fire-extinguishing equipment, the discussion given in this manual is of necessity general and does not cover all possible installations.

12. CONSTRUCTION. a. General. The fixed fire-extinguishing system consists of an adequate supply of carbon-dioxide gas stored in a steel cylinder, a release valve, tubing to direct the gas, and a control handle or automatic actuators to effect the release of the gas. A distributor valve or cock is included in manually operated systems having more than one discharge line.

b. Cylinders. The CO_2 cylinders used in extinguishing systems are identical with those used in flotation equipment, except for the size. The three most common sizes are the 5-, 7.25-, and 12-pound cylinders. The 5-pound cylinders are used in systems having only one discharge line. The 7.25-pound cylinders are used in systems having two or three discharge lines. The 12-pound cylinders are used mainly for extinguishers provided for compartments such as might be found around the wing fuel tanks in large aircraft.

c. Release mechanism. The manual release mechanism for fixed extinguishers consists of a small **T**-shaped release handle, a flexible cable, and

a cylinder release valve. The two types of valves commonly employed for this equipment are the quick-release and cutter types. The release cable (from the cylinder to the valve) is covered with small-diameter tubing to prevent accidental discharge of the extinguisher. Where it is necessary to make a change in the direction of the release cable, an adjustable corner pulley is used. This allows the use of only straight control cable tubing.

d. Supply tubing. The tubing from the cylinder valve to the compartment protected by the system is called "supply tubing." This supply tubing is made of aluminum alloy and normally has an outside diameter of ½ inch. Bends in the supply tubing are limited to radii greater than three times the outside diameter of the tubing, or in this case 1½ inches.

e. Distribution of gas. The distribution of the gas is effected by either "distributor tubing" or nozzles. What was said of "supply tubing" is also true of "distributor tubing," the only difference being that the latter is drilled with small perforations for the proper distribution of CO_2 and is made of stainless steel. A typical distributing system for an air-cooled engine is shown in figure 13. A ring of perforated tubing distributes the gas around the engine. Additional protection is provided by a length of perforated tubing running around the carburetor and a line which conducts CO_2 to a carburetor nozzle located in the carburetor intake. The arrows in this figure represent the discharge of gas.

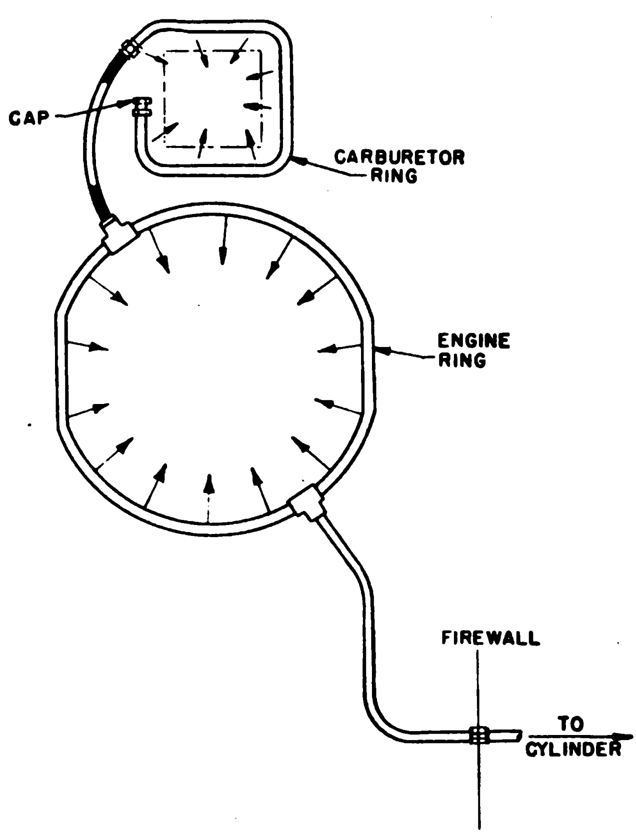


Figure 13. Schematic drawing—fixed fire-extinguisher distributing system.

f. Distributor valve. The distributor valve or cock used with multi-engine systems directs the output of the gas to the desired location. It is merely a selector valve. Some multi-engine airplanes are provided with an independent system for each engine. In this case no distributor cock is required.

g. Types. Fixed extinguisher systems may be manually or electrically operated. Manually operated systems are classified by the number of discharge lines used. An A–11 system has only one discharge line; an A–12 system has two discharge lines; and an A–13 system has three discharge lines. Figure 14 illustrates the manifolding and use of two A–12 systems on a four-engine airplane. A schematic drawing of an electrically operated fire extinguisher installation is shown in figure 15.

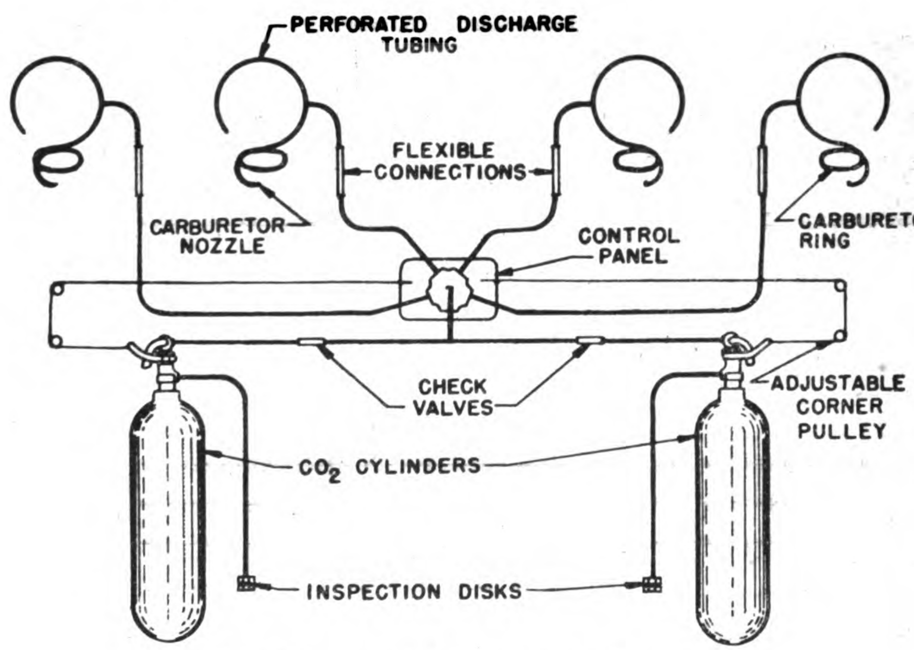


Figure 14. Fire extinguisher—multiengine installation.

13. OPERATION. a. Manually operated systems. Operation of the fixed type extinguisher in the case of an A–11 system is accomplished by pulling the control handle. Through the release cable this actuates the cylinder release valve and the CO_2 gas in a liquid state is forced through the supply tubing to the distributing system. Vaporization of the CO_2 takes place as it passes through the perforations in the distributing tubing or nozzles. In the case of an A–12 or A–13 system, it is necessary first to set the distributor cock and then pull the release handle.

b. Electrically operated systems. Electrically operated systems include an impact actuator in the fuselage and thermal (heat) actuators in each engine nacelle. (See fig. 15.) In case of an engine fire, the heat of the fire will cause the thermal actuator to complete an electrical circuit to a release valve similar to the one shown in figure 5. Completion of the elec-

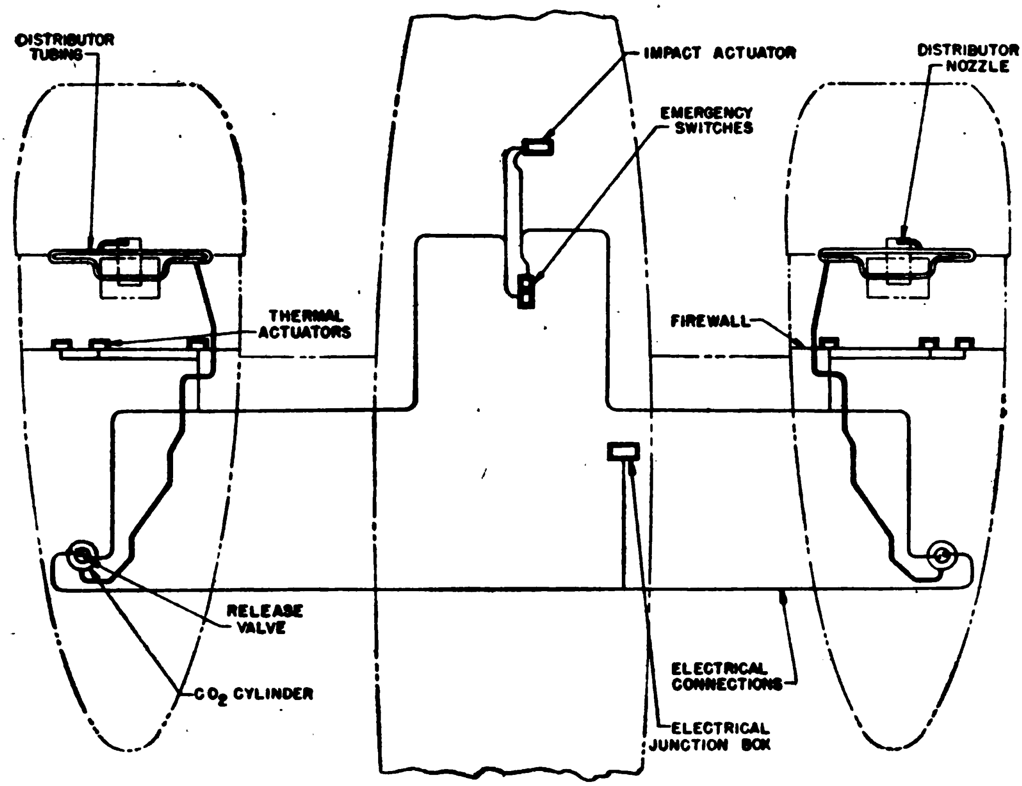


Figure 15. Electrically operated fire-extinguishing system.

trical circuit ignites a small charge of powder. Pressure developed by the burning powder acts on the diaphragm. This operates the release mechanism of the valve, thus putting the system into operation. In case of a crash, the impact actuator functions to put the system into operation. The system may also be operated by manually closing the emergency switches.

14. INSPECTION AND MAINTENANCE. The CO_2 cylinder in a fixed extinguishing system should be inspected as outlined in paragraph 3e. The extinguishing system tubing should be checked periodically for loose attachments, dents, corrosion, cracks, etc. The perforations in the distributor tubing should be checked with soft copper safety wire to see that they are open. Opening of these perforations, if they become clogged, should never be accomplished in such a manner as to enlarge them. Copper safety wire of the correct size and a blast of compressed air directed through the tubing will usually open them. The discharge cable should be lubricated periodically with grease, graphite, medium. Check the thermal actuators in electrically operated systems. Broken or browned filaments should be replaced. All wiring and tubing to the cutter valve should be disconnected before the cylinder is removed for charging. Before installing the cylinder, consult Technical Orders for the procedure to be followed.

SECTION V
PYROTECHNIC PISTOLS AND SIGNAL FLARES

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15. GENERAL. The pyrotechnic equipment discussed in this section is used for signaling purposes. Pyrotechnic pistols are used to discharge flares of various colors and types.

16. PYROTECHNIC PISTOLS. a. Type M–2 pistol. (1) This pistol or "projector" was developed to meet the requirement that the pilot be able to load, fire, and extract the empty signal or flare case with one hand. The barrel of the pistol serves as a seat or socket into which the detachable flare barrel is inserted. A locking lug on the pistol engages a groove in the base of the flare barrel.

(2) OPERATION. The barrel of the pistol is placed over the base of the flare, which is automatically locked in place. A continuous pull on the trigger cocks and fires the pistol. The detachable flare barrel is unlocked by depressing the thumb release on the left side of the breech of the pistol. It is then free to fall from the pistol. In case of misfire, the signal may be released in the same way.

b. Type AN–M8 pistol. (1) This pistol (fig. 16) is a single-shot, breech-loading pistol designed for use in aircraft. It is fired through the M1 mount, which is fastened rigidly to the airplane and is open to the outside. Springs in the mount take up the recoil. A cover, which may be installed or removed from the inside, is provided for the mount. This cover is replaced as soon as the pistol is removed.

(2) OPERATION. To prepare this pistol for firing, remove the mount cover and insert the lugs on the pistol barrel into the slots in the mount. The pistol is then rotated to the right or left until it is locked to the mount. The breech lock never is raised, allowing the breech to open. A signal is inserted in the chamber and the grip is pulled upward. The breech lock engages and the pistol is ready for firing. To remove the pistol from the mount, pull back on the mount release lever and rotate the pistol until the lugs and slots are lined up. Since the pistol may be discharged simply by pulling the trigger, a live signal must never be left in the pistol when it is removed from the mount.

c. Pistol holder. The pistol holder is made of canvas. The pistol is inserted in the holder with the trigger guard down and the breech latch

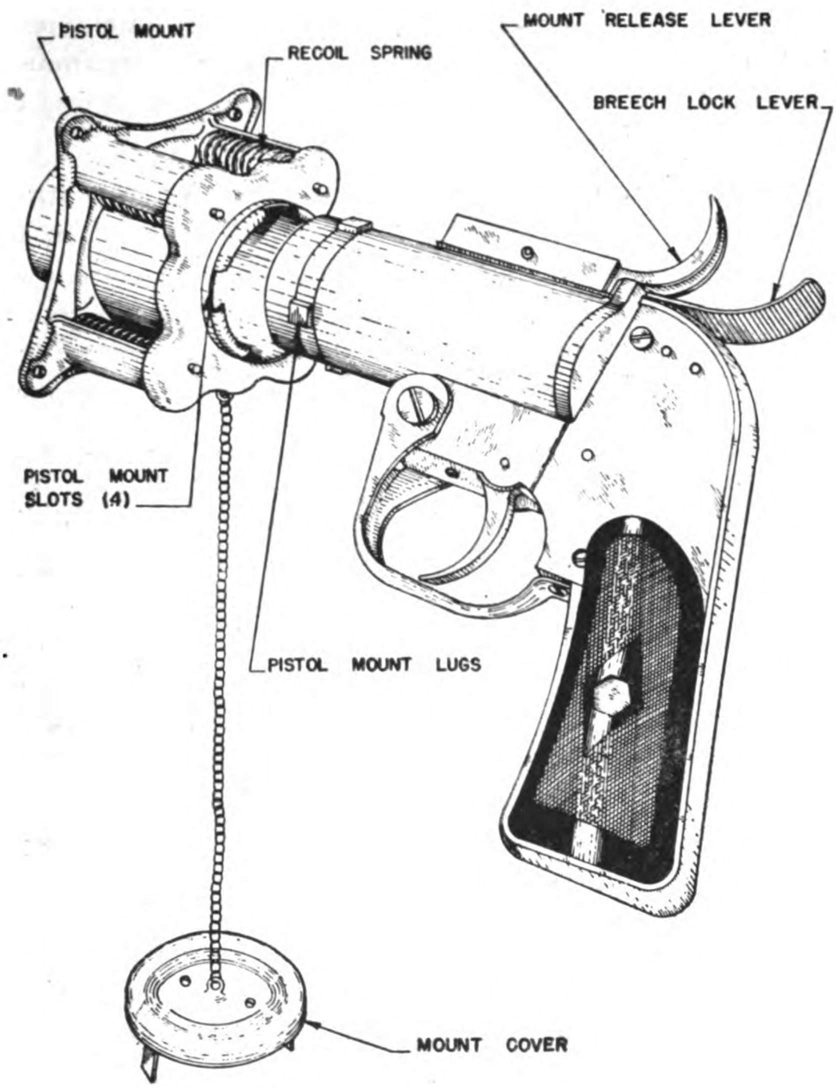


Figure 16. AN–M8 pyrotechnic pistol.

uppermost. Straps with snap buttons bind the holder to the signal container and hold the pistol securely in the holder.

d. Inspection and maintenance. (1) Pyrotechnic pistols should be kept clean by wiping with a clean cloth which is free of lint. A few drops of machine-gun oil on the moving parts is sufficient lubrication. Pistol holders should be inspected for ripped seams and torn material. Snap buttons should be checked for ease of operation and rigidness when closed. Defective holders should be repaired or replaced.

(2) In order to keep moisture out of upward-firing pistol mounts, when airplanes are being serviced, a single layer of masking tape should be placed externally over the opening in the airplane skin. Upon firing of the pistol, charges will penetrate the tape without ill effect.

17. SIGNAL FLARES. a. General. Many different types of signal flares may be fired from pyrotechnic pistols. These flares may have aluminum or

cardboard shells. They may or may not be of the parachute type and may be of different colors. The color of the signal may be determined by the color of the top of the shell. In some cases, the type and color of the signal is stenciled in black letters on the side of the shell.

b. Signal-flare containers. These containers (fig. 17) are made of canvas. A separate pocket is provided for each flare. The flares are inserted into the pockets of the container with the firing caps down so that the signal colors may be easily distinguished. A slide fastener opening provides for easy insertion or removal of the flares. Technical Orders should be consulted for instructions as to the placement of the container in the airplane.

c. Precautions. (1) When discharged, pistol flares should never be so directed that they will injure other personnel or any part of the airplane. When used on the ground or a raft, they should always be directed vertically upward. If a flare does not fire on the first attempt, two more attempts should be made. If it still does not fire, keep the pistol pointed away from the airplane for at least 30 seconds. A misfired flare should never be handled while it is being removed from the pistol. It should be permitted to fall clear in such a manner that it will not strike any part of the airplane. During flight over populated or forested areas, or when delay is desirable for other reasons, the pistol may be returned to the holder to await a more suitable place or time for discarding the flare.

(2) Care should be exercised not to damage or break the waterproof seal in the end of the case.

(3) Care should be taken to avoid denting or deforming the aluminum case.

(4) Allow no object to rest on, strike, or press upon the primer.

(5) Signal cases which have serious dents or which are so damaged that they will not fit properly into the projector will not be used.

(6) Do not allow the signal case to come in contact with oil or grease.

(7) All foreign substances, such as dirt, sand, mud, or grease, will be carefully removed before use.

d. Inspection and maintenance. At periodic inspections the following procedure is observed:

(1) Open and close the slide fasteners of the containers to make certain that they work easily, and check the presence of the correct number of flares.

(2) Inspect the flare container for ripped seams or torn material. Replace any items found in unsatisfactory condition. If the station is equipped for such work, minor rips and tears should be repaired locally.

(3) Inspect the straps holding the container. They must release easily in case of emergency.

(4) See that the container is securely strapped in place.

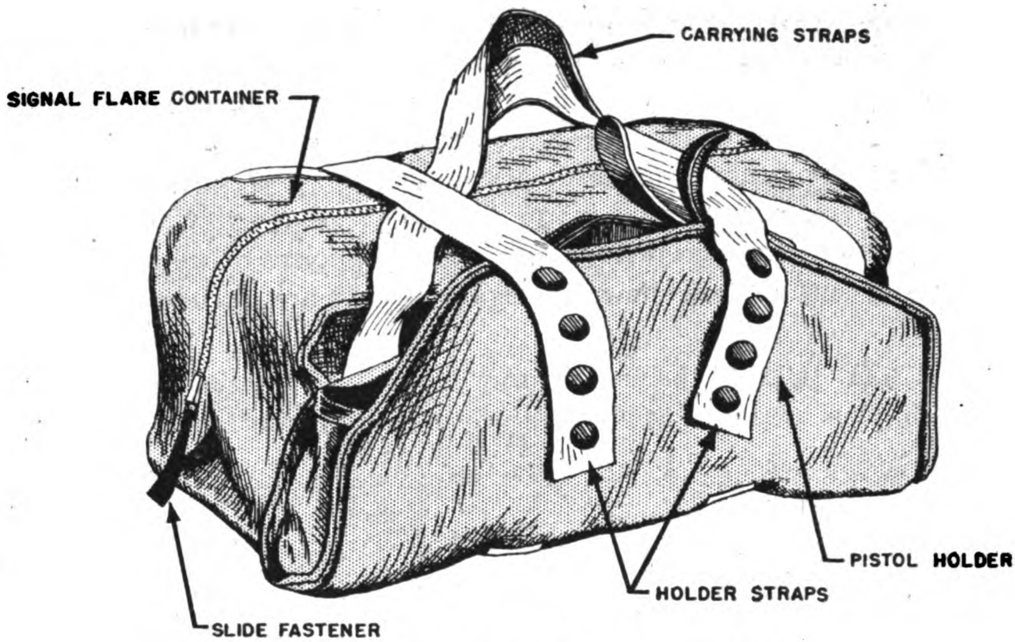


Figure 17. Signal-flare container and pistol holder.

SECTION VI
ICE-ELIMINATING EQUIPMENT
(Inflatable Shoe Type)

18. GENERAL. The danger due to the formation of ice on aircraft during certain flight conditions makes it highly important for all concerned to understand the conditions of ice formation and the kinds of equipment used to combat it. In this section the de-icer equipment for airplane wings, tail surfaces, radio loop, and masts is discussed. Anti-icer equipment for propellers, carburetors, and airspeed tubes is discussed in other manuals.

19. NATURE OF ICE FORMATIONS. a. Primary conditions. The following primary conditions must be present for ice to form on an airplane: (1) Moisture must be present in visible form, as clouds, fog, mist, rain, snow, or sleet. Snow and sleet are especially conducive to ice formation. (2) The temperature of the atmosphere must be 34° F. or less. The most dangerous temperature range is from 20° to 32° F. (—7° C. to 0° C.).

b. Types of ice formations. The principal forms of ice accumulation on aircraft surfaces are shown on figure 18 and are discussed in the following:

(1) GLAZE ICE. If the temperature is near the freezing point and the water droplets are large, so that they wet the aircraft surfaces, glaze ice will

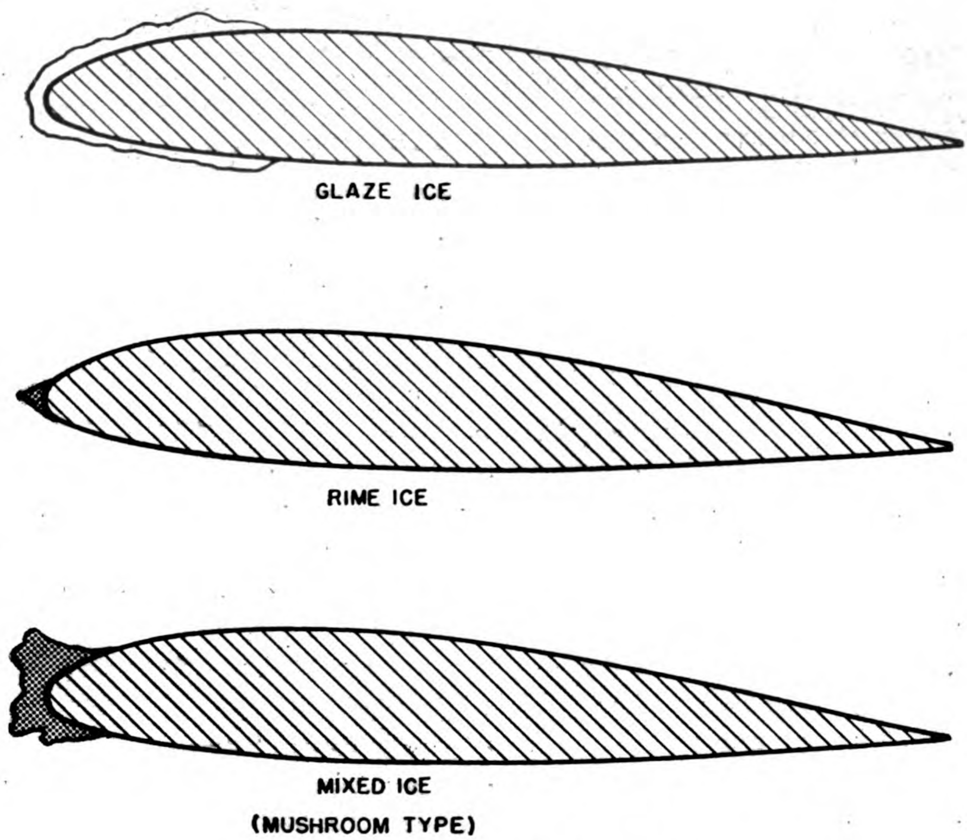


Figure 18. Types of ice formations.

form on the leading edges of the wings, tail, radio mast, pitot mast, etc. Glaze ice, being clear, is often difficult to detect until an appreciable quantity has formed. Glaze ice conforms closely to the contour of the wing, except for lumps and protuberances which sometimes form aft of the leading edge as a result of "runback" of water droplets prior to freezing. These protrusions increase the drag of the wing.

(2) RIME ICE. If the temperature is well below freezing and the water droplets are very small, rime ice will form on the leading edges of the air-

craft. Since the tiny droplets turn to ice almost instantly when struck by the airplane, the surfaces are not wetted. As a result rime ice has an opaque, whitish, granular appearance quite different from glaze ice. Since there is no "runback" the ice accumulates only at the extreme leading edges, usually in a pointed form as shown in figure 18. At low angles of attack, the pointed formation may be relatively harmless. However, at higher angles of attack, the pointed edge will act as a spoiler, seriously disrupting the flow of air over the upper wing surface.

(3) MIXED ICE FORMATIONS. Only rarely does ice form either as pure glaze or pure rime. Usually the accumulation is a combination of the two types formed either simultaneously or one type over the other. Mixed accumulations often take peculiar forms. The blunt "mushroom" shape shown in figure 18 may occur, greatly increasing the drag of the wing and reducing its lift. Sometimes the freezing rain may be mixed with snow. Near the freezing point, soft mushy formations may build up. These bend readily with the distortions of the inflatable shoe, yet cling tenaciously to it.

(4) FROST. In cold climates, and particularly in Arctic regions, frost will often form on the upper surfaces of parked aircraft during cold, clear nights. Such frosting can be prevented by means of wing covers and paulins. Sometimes anti-icing pastes or fluids are applied to the wings and tail surfaces before nightfall in order to facilitate the removal of frost formations the following day. Take-offs should never be attempted until all frost which has formed on the wings, tail, and control surfaces has been carefully removed. Failure to observe this rule can result in loss of control or insufficient lift during take-off. Frost may also form on an airplane during flight in clear air if a rapid descent is made from high altitude into a layer of warm humid air. Such frost will disappear as soon as the aircraft surfaces have become warmed to the temperature of the surrounding air. This type of frosting may even occur during a climb, if an inversion exists.

20. DE-ICING EQUIPMENT. a. Purpose. Since the weight of accumulated ice would create an extra load, and since ice formations would alter the aerodynamic characteristics of the airplane, icing condition must be avoided or ice which has formed must be eliminated as quickly as possible. De-icer systems are used to prevent the continued accumulation of ice on airplane wings, tail surfaces, radio loops, and masts. This is accomplished by the periodic inflation of rubber shoes attached to the leading edges of these parts of the airplane.

b. Heavy bomber de-icer system. The de-icer system for a heavy bombardment type airplane usually employs the following basic units: Two vacuum-pump assemblies, check valves, an ON-OFF air control valve with electric switch, and air-filter unit with pressure-regulating valve, an electrically driven distributor valve, inflatable rubber shoes, and connecting tubing. A schematic drawing of a system of this type is shown in figure 19.

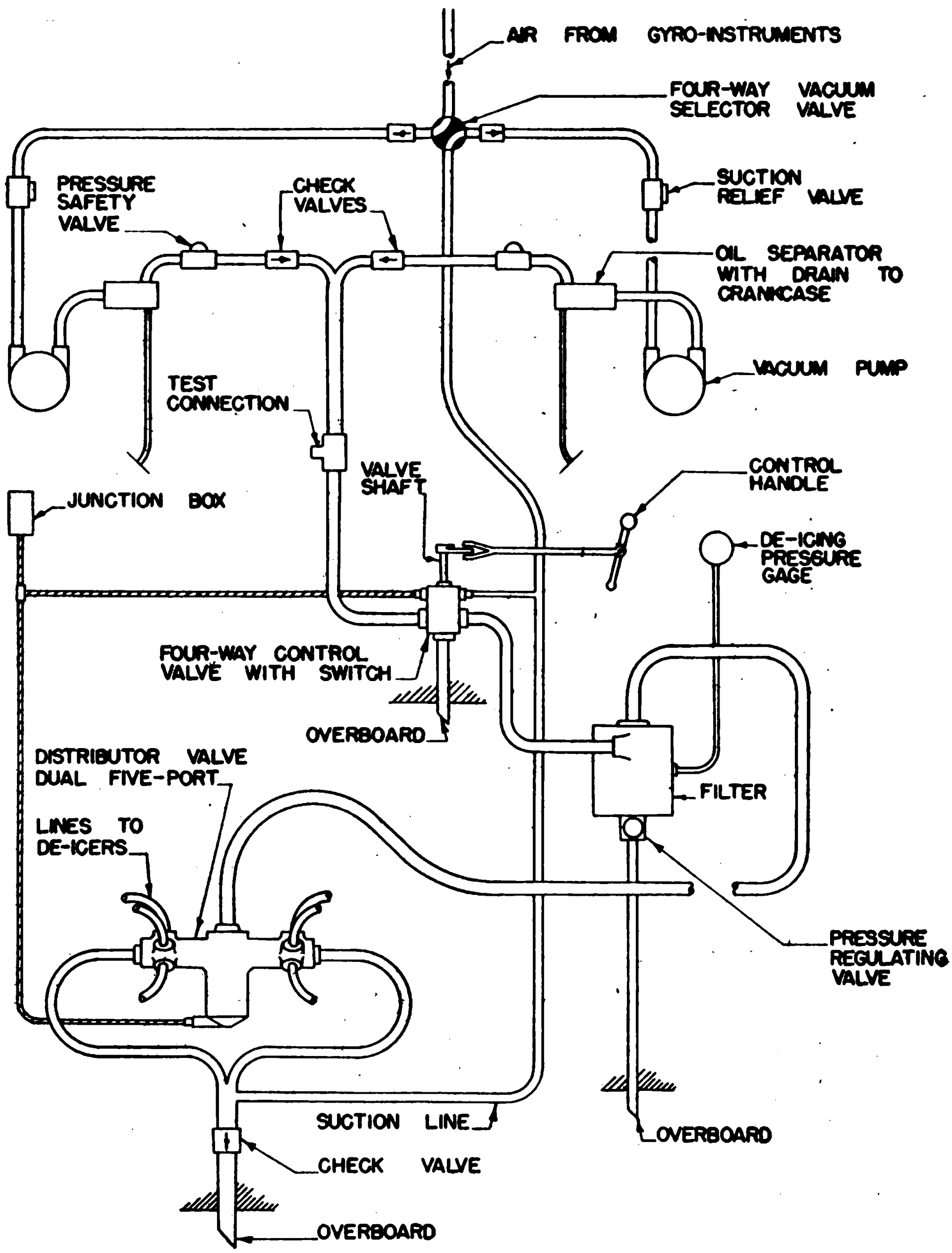


Figure 19. Typical de-icer piping system (heavy bomber).

(1) VACUUM-PUMP ASSEMBLIES. The engine-driven vacuum pumps provide the compressed air for operating the inflatable shoes. The vacuum pumps are so named because they provide suction for operating the flight instruments. The exhaust air from the pumps is used only during de-icer operation. Each vacuum-pump assembly consists of the pump itself, a suction-relief valve, an oil separator, and a pressure safety valve. Descriptions of these parts are as follows:

(*a*) *Vacuum pump proper.* Each vacuum pump is of the rotary, four-vane, positive-displacement type and is mounted on the accessory drive-pad

of a separate engine. Lubrication is provided from the engine oiling system. A typical vacuum pump is shown in figure 20.

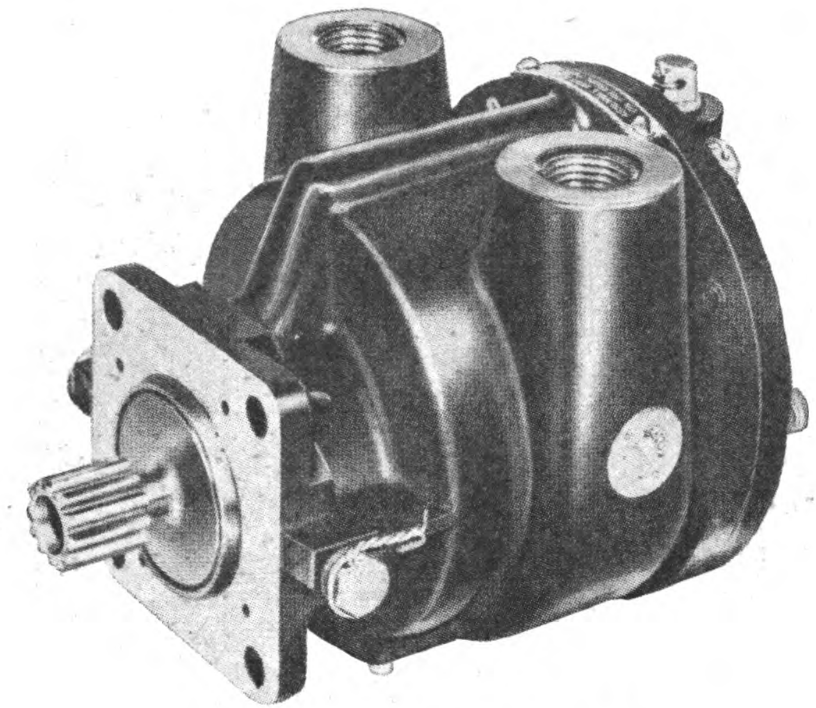


Figure 20. Typical vacuum pump.

(*b*) *Suction-relief valve.* The suction-relief valve is of the spring-loaded type and is placed in the suction line near the inlet port of the pump. Its function is to prevent the suction at the pump inlet from exceeding a predetermined value, usually approximately 5 inches Hg suction. An excessive suction load would reduce the output of the pump and cause it to overheat. A typical suction-relief valve is shown in figure 21.

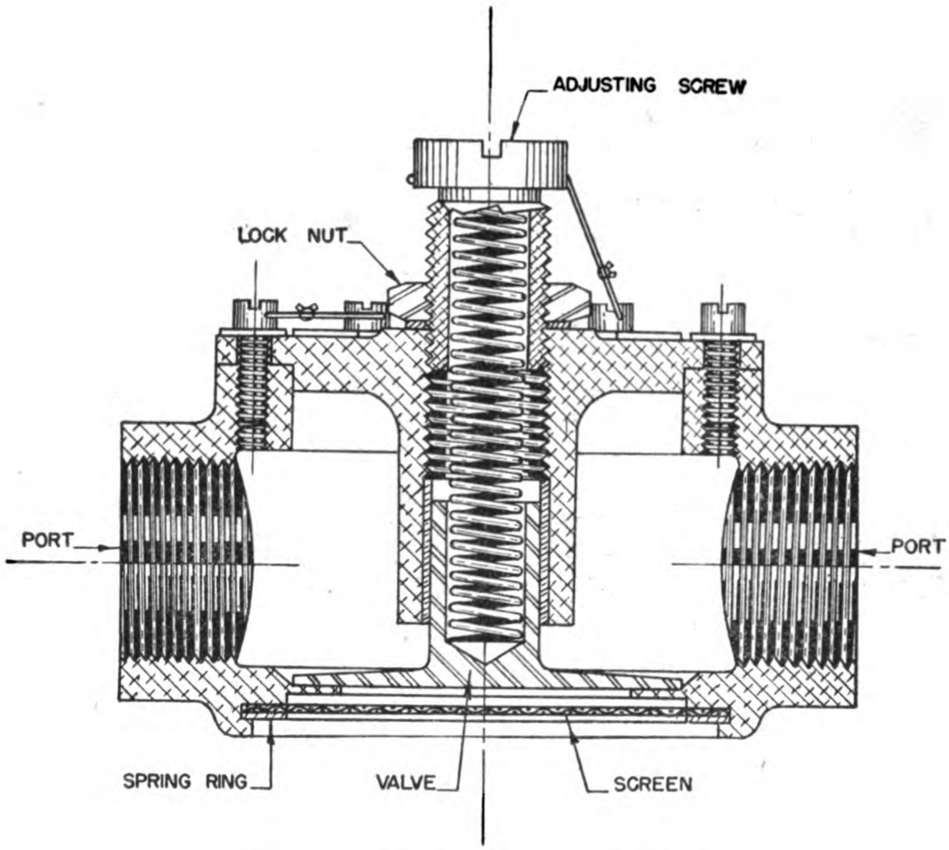


Figure 21. Typical suction-relief valve.

(*c*) *Oil separator.* The purpose of the oil separator is to remove oil from the air discharged by the pump and return it to the crankcase. The

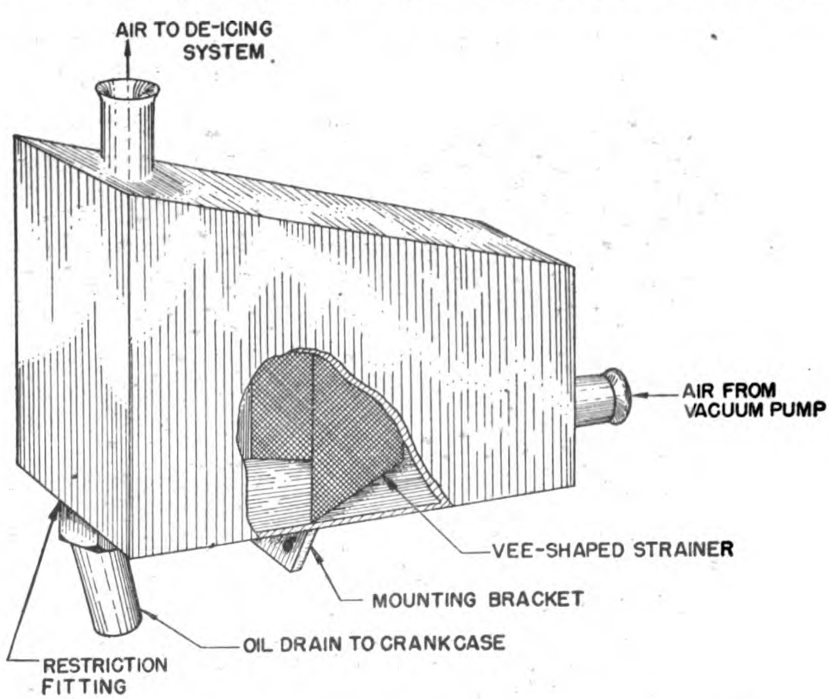
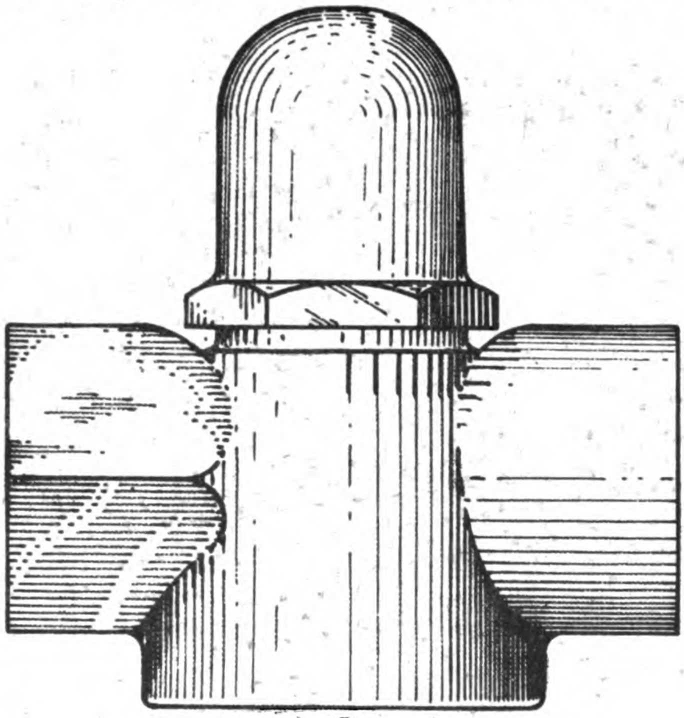


Figure 22. Typical primary oil separator (gravity type).

oil separator is usually box shaped with connections for air inlet, air outlet, and oil drain. It contains no moving parts. Most types incorporate a strainer to improve the separation. A restriction is placed in the oil-drain outlet to prevent excessive leakage of air to the crankcase. One type of oil separator is illustrated in figure 22.

(*d*) ***Pressure safety valve.*** The pressure safety valve is of the spring-



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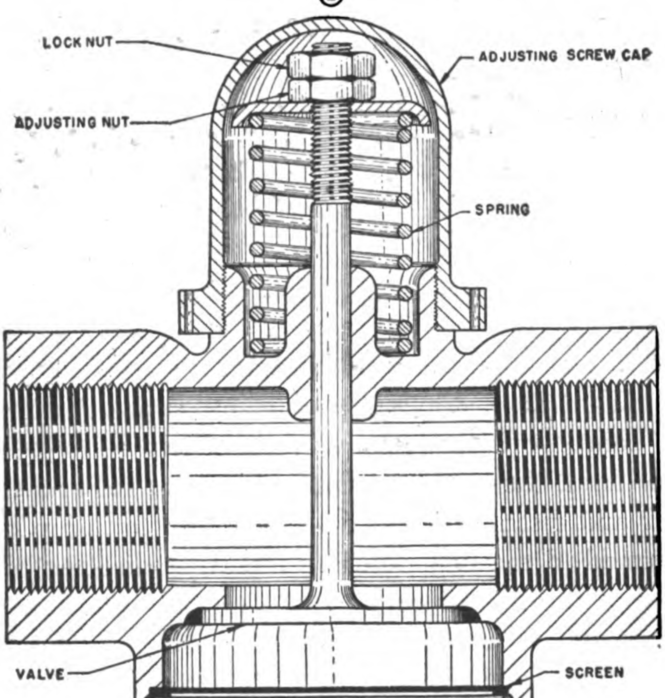

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Figure 23. Typical pressure relief valve.

loaded type, and is designed to open when the pressure at the pump outlet exceeds approximately 18 inches Hg. Should parts of the piping system (downstream from the valve) become clogged, the valve will protect the pump from excessive back pressure and consequent overheating. A typical pressure safety valve is shown in figure 23.

(2) CHECK VALVES. A spring-loaded, hinged flapper type check valve is placed in each vacuum-pump exhaust line. Thus, should one of the pumps fail during de-icer operation, its check valve will close and prevent loss of air from the system. For ground tests, the de-icing system is sometimes connected to an external supply of compressed air. In such cases, both check valves close, preventing reverse flow through the vacuum system and possible damage to the flight instruments. A typical check valve of this type is shown in figure 24.

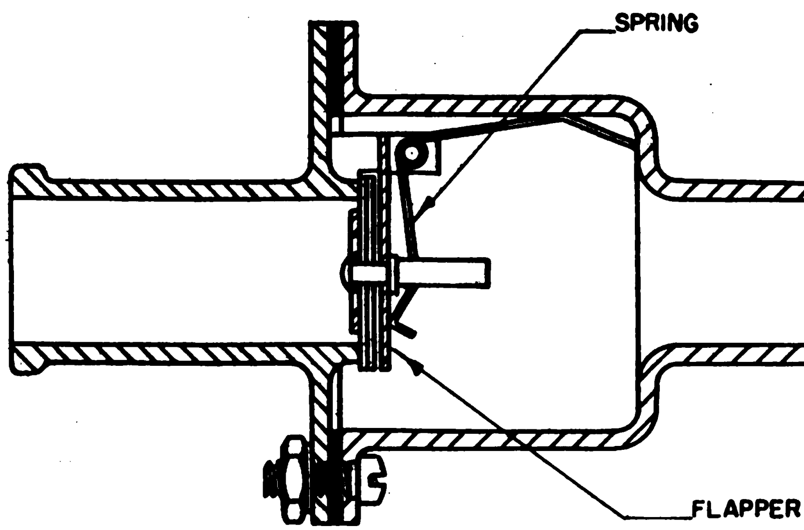


Figure 24. Typical air check valve.

(3) CONTROL VALVE.—The air streams from the two pumps are merged at the Y fitting and carried through a single line to the four-way control valve. The valve is operated by means of a control handle located in the pilot's compartment. The valve has two settings. In the OFF position the air from the pumps is dumped overboard and the line leading to the air filter and distributor valve is connected to pump suction. When the valve is turned to the ON position, the air is directed to the inflatable shoe system, the dump and suction ports being blocked. The electric switch, built into the control valve, operates with the valve and is wired in series with the distributor valve motor. Thus, when the control valve is turned to the ON position, the switch closes and the distributor valve commences to rotate. When the valve is turned to the OFF position, the

switch opens and the distributor valve stops rotating. A typical four-way control valve is illustrated on figure 25.

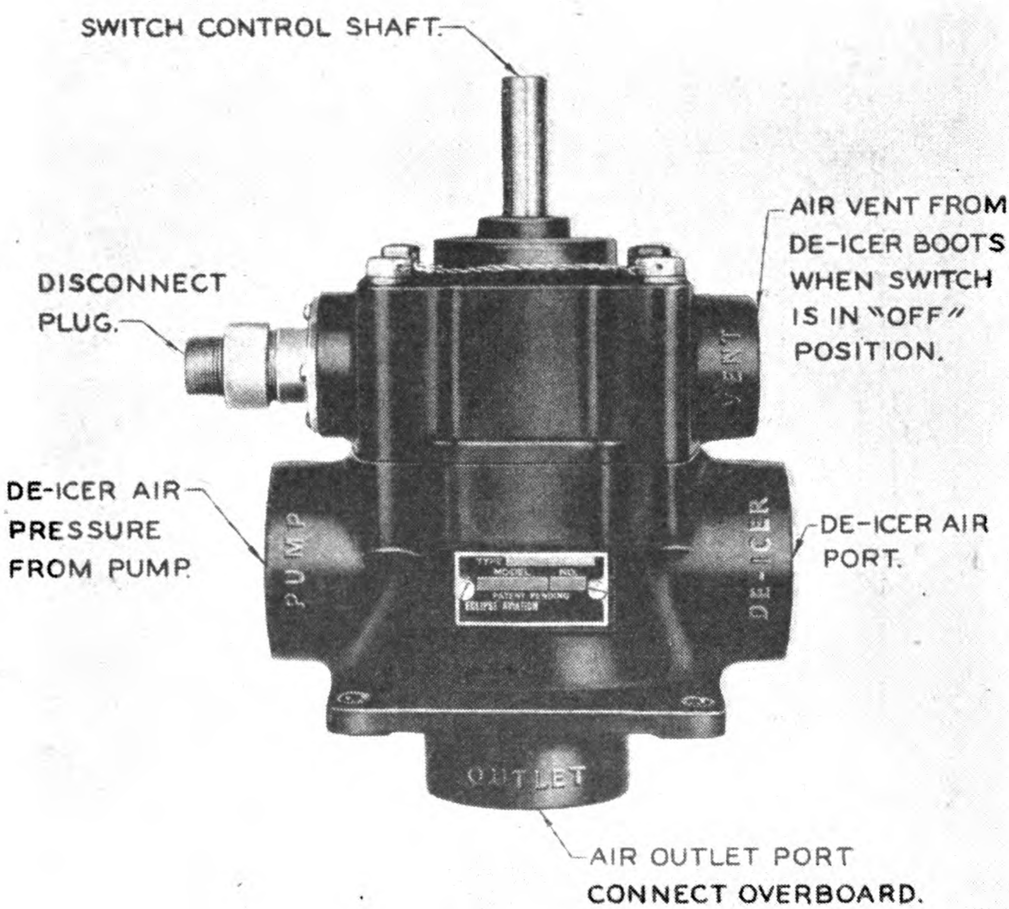


Figure 25. Typical four-way control valve.

(4) AIR FILTER. The air filter (see par. 27) is a secondary oil separator used to purge the air of oil not removed by the primary oil separators. The air enters the cylindrical chamber near the top. The inlet is located in such a way as to cause the air to swirl around inside the chamber. Centrifugal force causes some of the oil droplets to separate from the air and contact the wall of the chamber. The oil thus separated flows down the wall and into a sump near the bottom of the unit. The air upon reaching the lower part of the chamber moves upward through a central, copper-mesh filter and leaves the unit through a port at the top. An adjustable pressure-regulating valve is located at the bottom of the unit. This valve is adjusted to maintain the system pressure at 8 pounds per square inch. Since the pumps supply

more air than is required to inflate the de-icer shoes, the valve opens during the inflation of each group of cells and the oil collected in the sump is blown out through the discharge line along with the excess air. A pressure gauge in the pilot's compartment is sometimes connected to the port in the side of the air-filter unit.

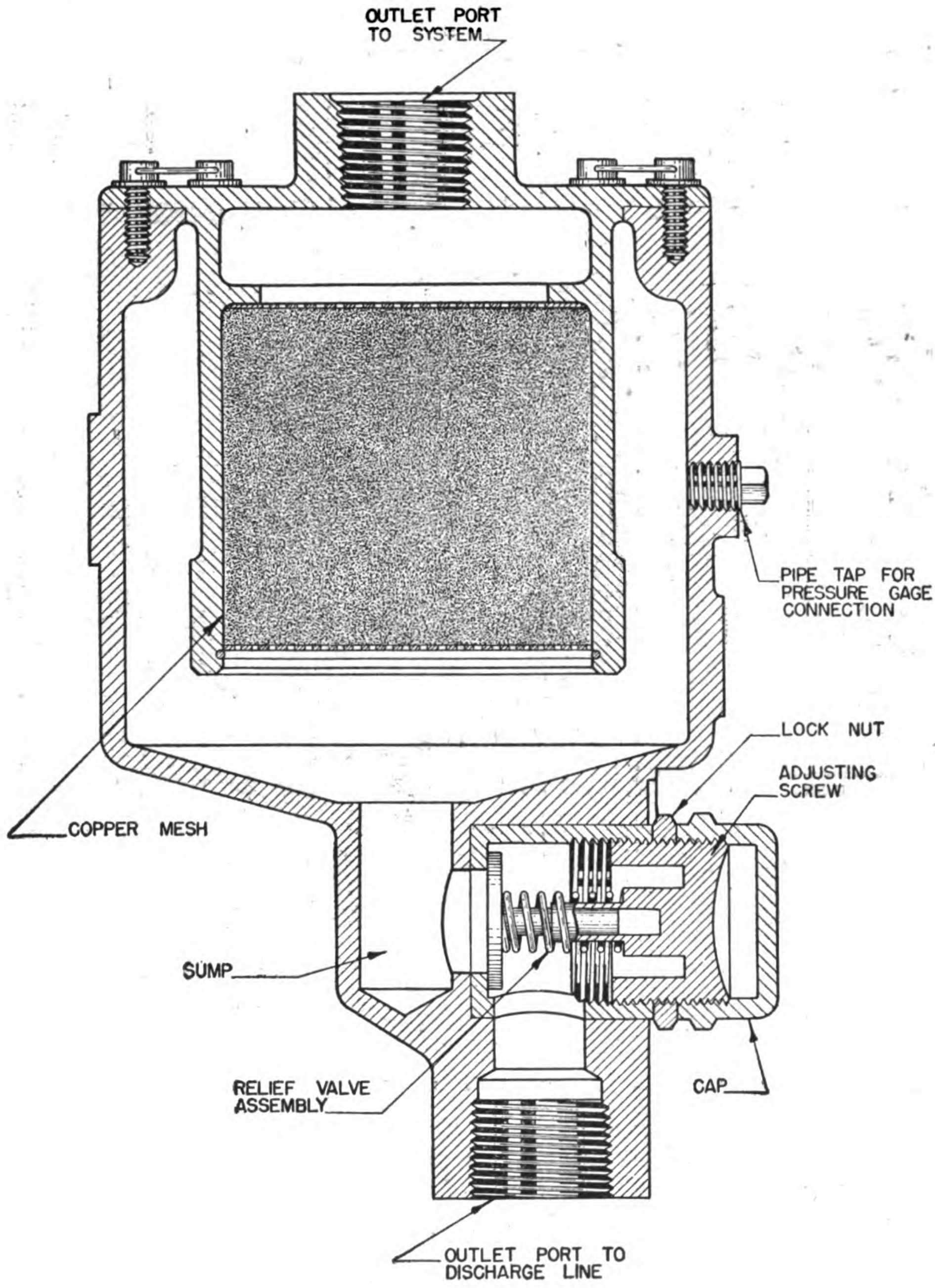


Figure 26. Typical de-icing air filter.

(5) DISTRIBUTOR VALVE. The purpose of the distributor valve is to direct the flow of compressed air from the pumps to each of the five de-icer tube inflation groups in periodic sequence. The distributor valve is of the double-ended type as illustrated in figure 27. Five outlet ports are

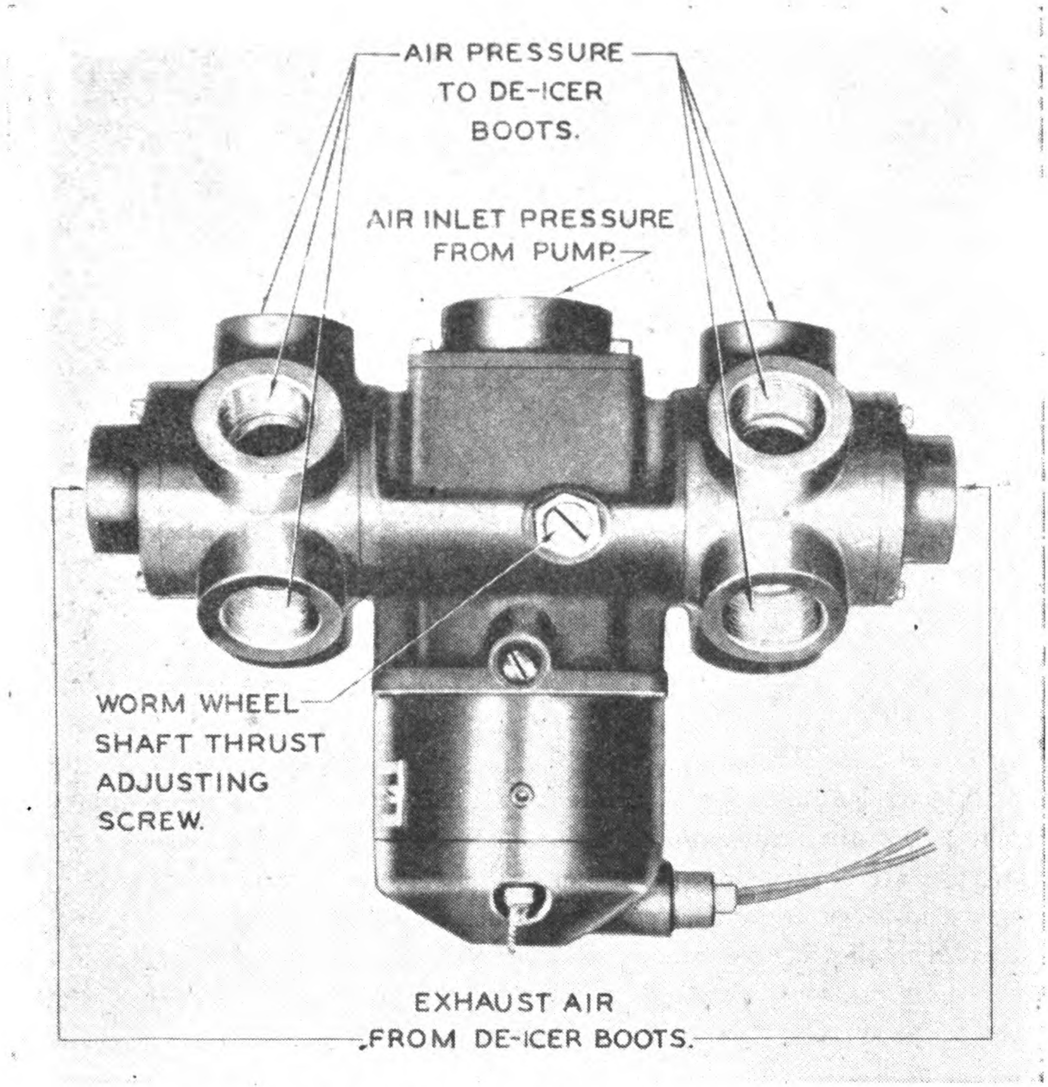


Figure 27. Typical double-ended de-icer distributor valve.

arranged radially around each end of the valve housing. Inside each end is a hollow **V**-shaped rotor. The two rotors are connected by a shaft which is geared, near its midpoint, to the electric motor. During operation the two rotors revolve as a unit. Air enters through the inlet port, divides, and flows into the **V** of each rotor. Each rotor directs the air through one radial outlet port at a time. Thus, air is supplied to the de-icer tubes through symmetrical pairs of radial outlet ports. Four of these pairs are connected to the wing shoes, each end of the valve serving one wing. The fifth pair is connected together by means of a **Y** fitting and supplies air to the tail de-icers. These connections are shown in figure 28. The valve requires 40 seconds to complete one cycle of operation. Each of the five inflation groups is inflated for 8 seconds after which it is free to deflate. Return air from the de-icers is discharged overboard through the two exhaust ports at the extreme ends of the valve.

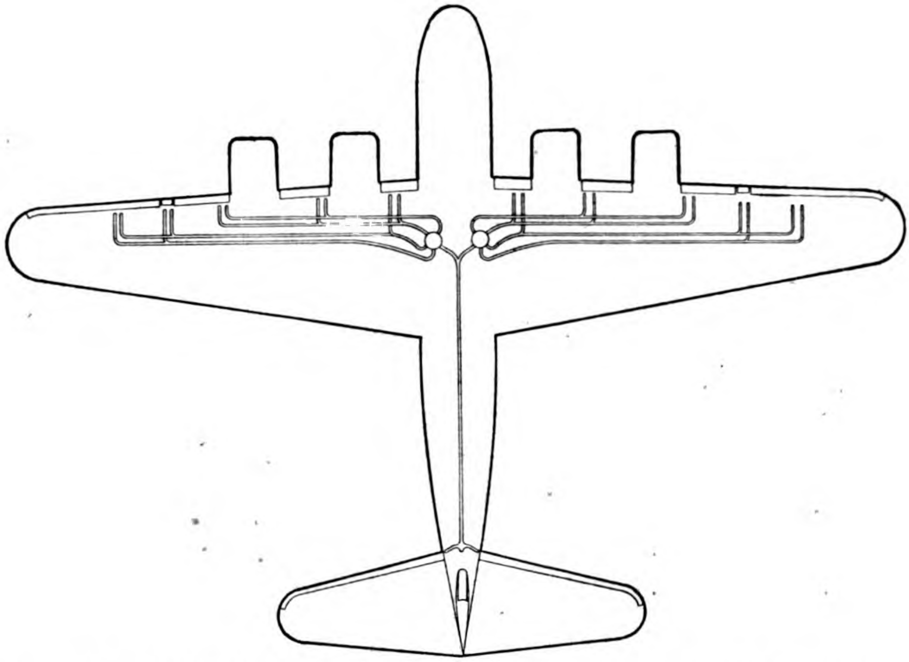


Figure 28. Air lines from distributor valve to de-icer—(heavy bomber).

(6) DE-ICER SHOE. A de-icer shoe is essentially a sheet of soft rubber covering the leading edge of the surface it protects. Two or more inflatable fabric tubes are built into its central portion. The tubes, which extend spanwise, are bordered by the upper and lower elastic "stretch areas." The upper and lower edges are reinforced with fabric and beadwire. The ends are reinforced with fabric. The outer ply of the shoe is of neoprene to resist deterioration by sunlight. The outer neoprene ply is coated with a layer of conductive cement to prevent the accumulation of an electrostatic charge on the leading edge during flight. The construction of a typical

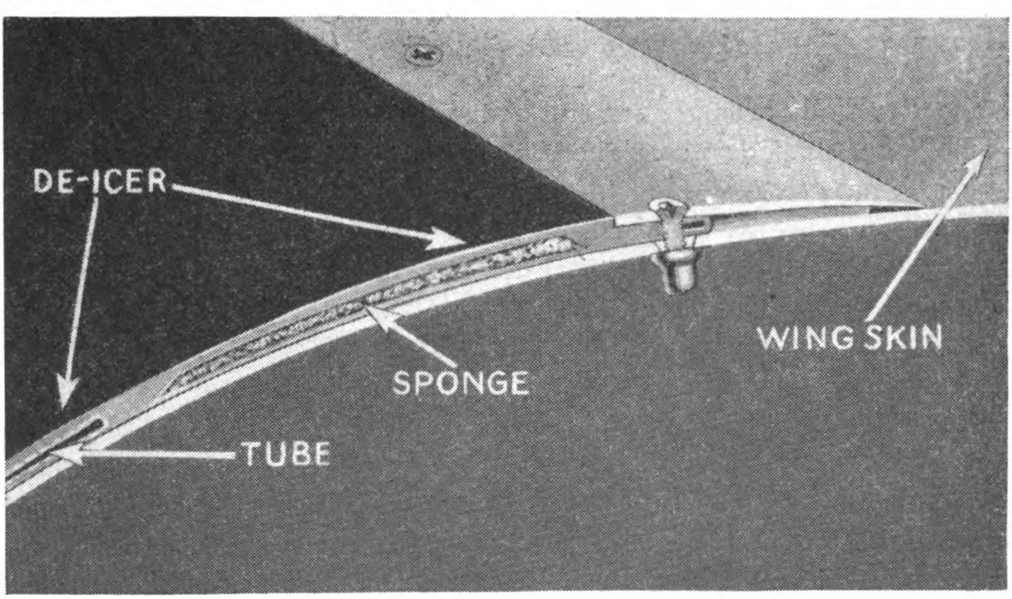


Figure 29. Typical de-icer shoe construction.

de-icer shoe is illustrated on figure 29. Fabric reinforcing strips, running chordwise from edge to edge at intervals of approximately 10 inches, are built into the shoe to prevent small tears from extending spanwise. Small vent holes are provided in the reinforcing strips. These holes permit the escape of air which might otherwise become trapped beneath the shoe and cause it to "lift" from the skin. Most de-icers are attached to the skin only at the edges by means of attachment screws, hollow threaded rivets,

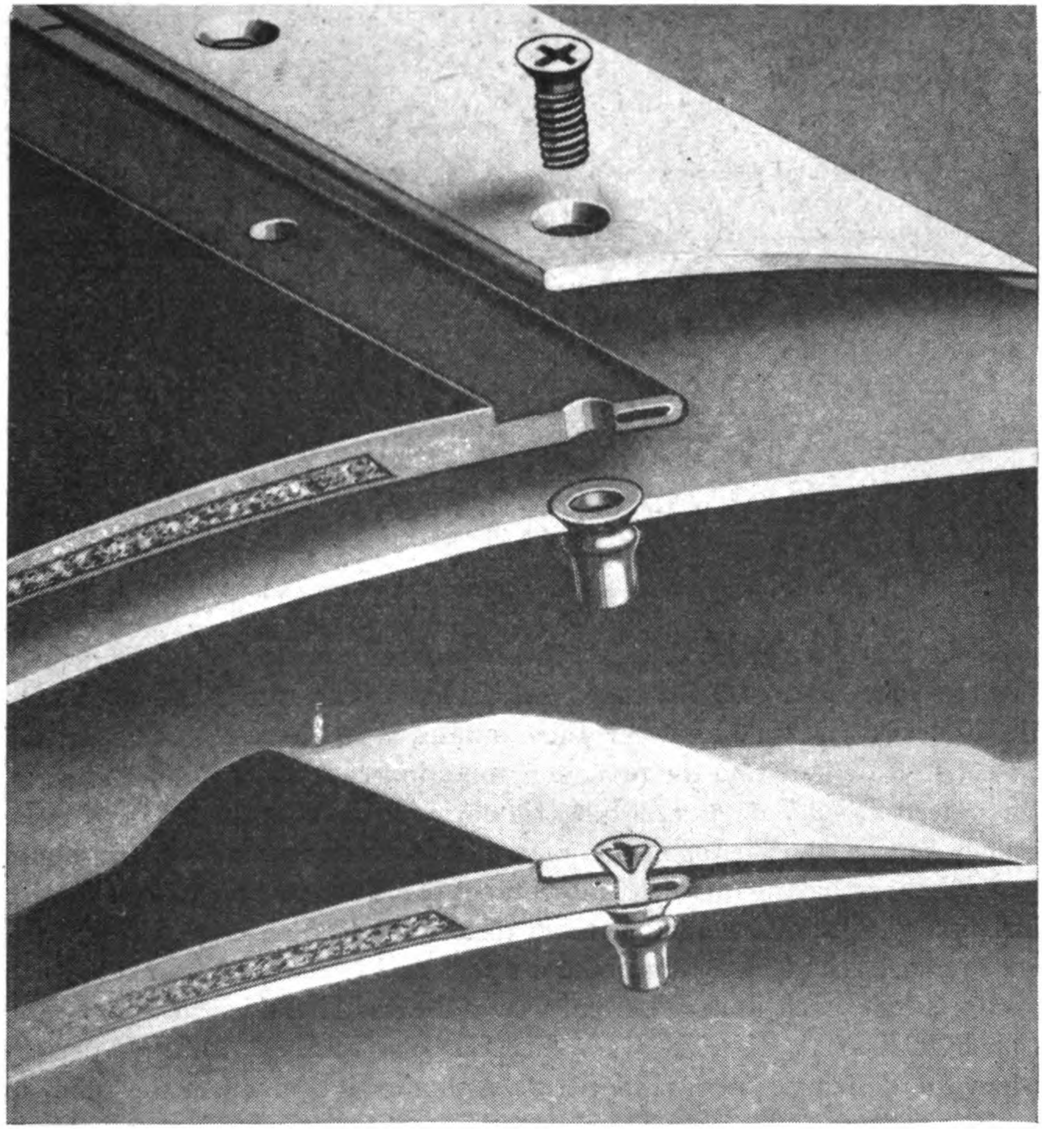


Figure 30. Typical de-icer attachment showing fairing strip.

and fairing strips. (See fig. 30.) On some de-icers fabric snubber flaps are provided on the under side to prevent creeping of the shoe toward the upper attachment. The edge of such a flap is reinforced with a flat metal bead and is fastened to the skin by means of attachment screws and hollow threaded rivets. The ends of the shoe are fastened by means of chordwise metal strips, called end clamps, which are held down by means of attach-

ment screws and hollow threaded rivets. Clamp rings are used in the same way where holes must be provided through the shoe for inlet ducts in the leading edge. Metal air-connection stems are provided to admit air to the tubes. Nonkink rubber hose is used to connect these stems to the piping system inside the leading edge. Rubber grommets are placed in the

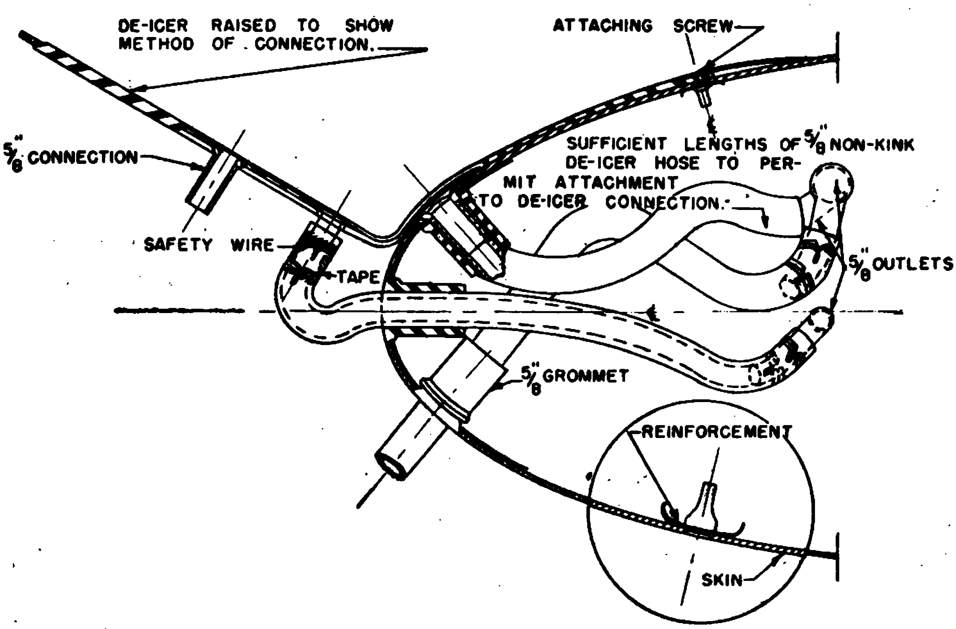


Figure 31. Typical de-icer connections through leading edge.

holes in the leading edge to prevent chafing of the hose. (See fig. 31.) On two-tube de-icers, both tubes inflate and deflate simultaneously. On three-tube de-icers, the center tube inflates first. After 8 seconds, the center tube deflates and the two outer tubes inflate. After 8 more seconds, the outer tubes deflate and all tubes lie dormant for 24 seconds. The cycle is then repeated. The operation of a three-tube de-icer is shown in figure 32. All shoes having three or more tubes are inflated as two consecutive inflation groups. The inflated tubes distort the leading edge, causing the ice to crack. The elongation of the upper and lower stretch areas, which occurs during each inflation, breaks the adhesion of the ice to these areas.

(7) FOUR-WAY VACUUM SELECTOR VALVE. During periods when the de-icing system is inoperative, suction is applied to the tubes to insure complete deflation. The connection to pump suction is usually made through a four-way vacuum selector valve as shown in figure 19. Should the pump which is operating the flight instruments fail, the valve can be turned to the alternate position. Thus, instrument operation, which is more important than de-icer suction, can be maintained. The de-icer suction line has two branches. One leads to the suction vent port of the four-way control valve and connects to suction the group toward which the U-shaped rotor in the distributor valve happens to be directed. The other branch of the suction line is connected to the overboard de-icer

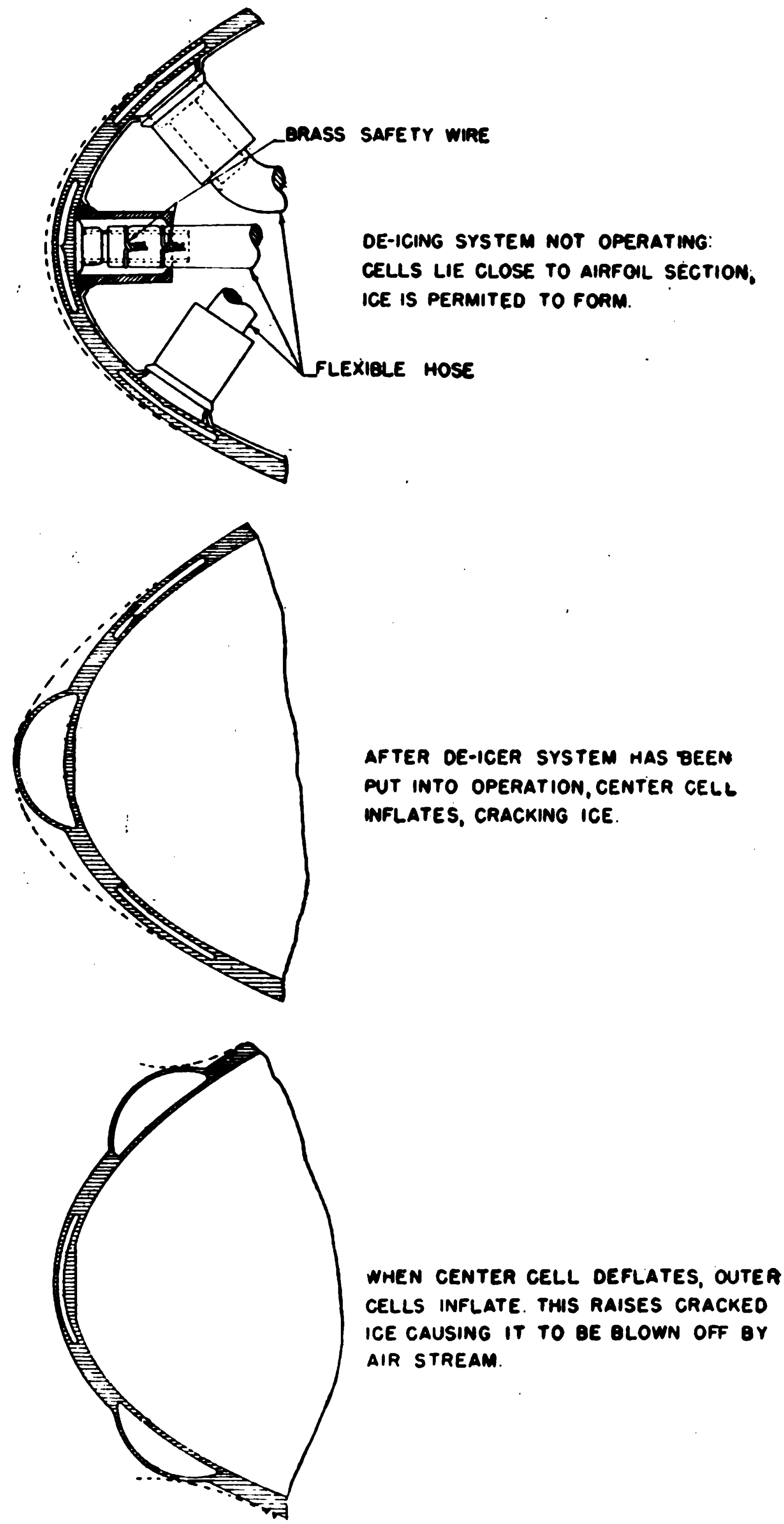


Figure 32. Order of inflation—three-tube shoe.

exhaust line. When suction is applied to this line, the check valve near the overboard outlet closes and suction is applied to the remaining four inflation tube groups.

(8) TEST CONNECTION. A test connection is provided in the piping system, usually upstream from the control valve, as shown in figure 19. The purpose of the connection is to provide means for conveniently connecting the system to an external source of air when it is desired to ground test it without having to operate the pumps. The test connection may be either a three-way plug valve or a "tee" fitting with a removable plug screwed into the side opening.

c. Medium bomber and cargo type airplane piping system. A typical de-icer piping system for a medium bomber or cargo type airplane

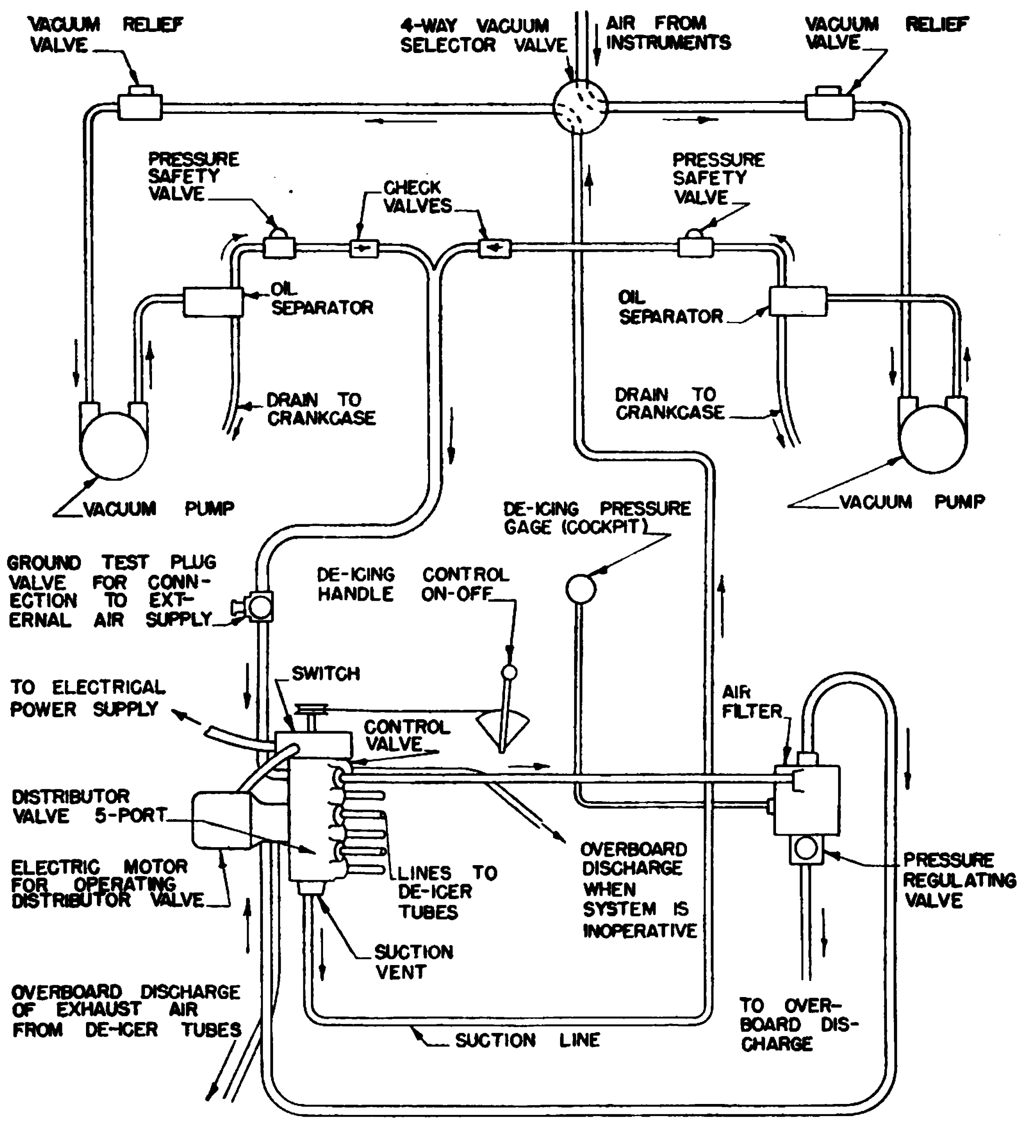


Figure 33. Typical de-icer piping system (medium bomber or transport).

is shown in figure 33. It is similar to the system for a heavy bomber, except that the control valve and switch are mounted on the end of a five-port distributor valve. The suction vent port is at the opposite end of the assembly and connects all of the inflation groups to suction during periods

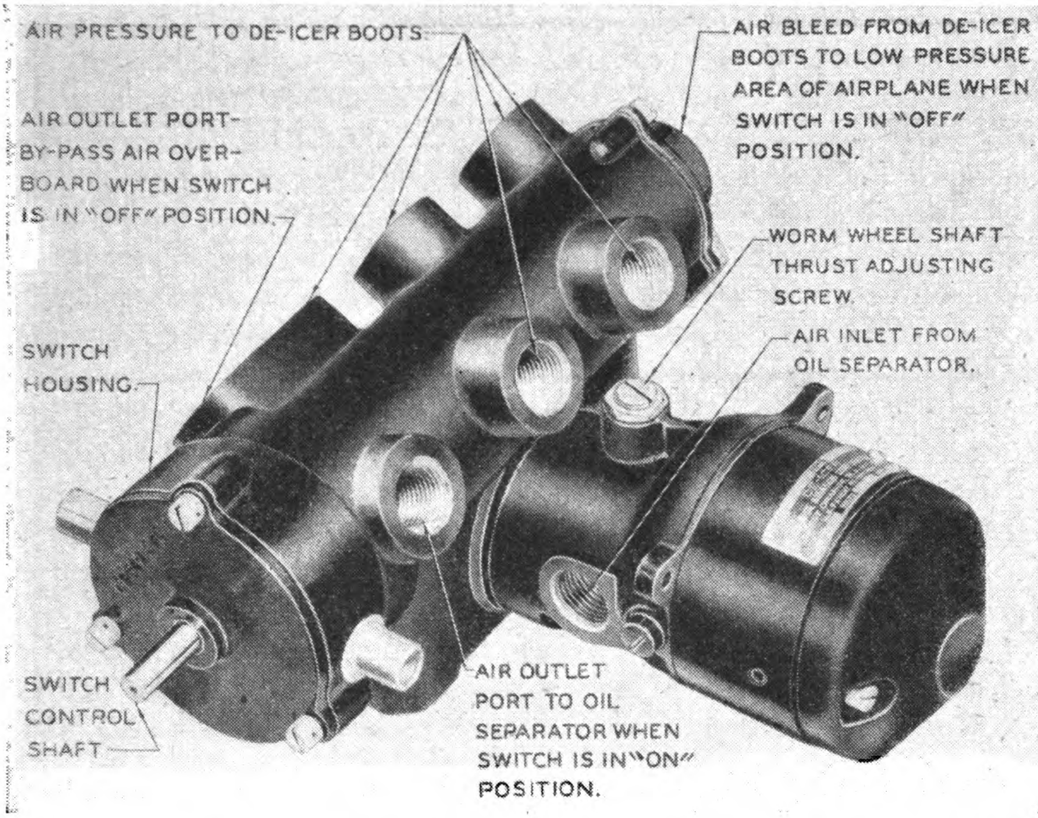


Figure 34. Typical five-port distributor valve with integral control valve and switch.

when the system is inoperative. The unit is shown in figure 34. On some airplanes in this category, a snap-action type distributor valve is used. A Geneva stop mechanism snaps the rotor from one port to the next. The tubes therefore inflate and deflate more abruptly, resulting in more efficient ice removal. Also, with snap-action type valves, suction is applied to the tubes between inflations as well as during periods when the system is inoperative.

d. Manifold type de-icer piping system. The manifold type system is used on very large airplanes where centrally located distributor valves would not be practicable. A typical manifold system is shown in figure 35. The parts comprising this system are as follows:

(1) PRESSURE MANIFOLD. The pressure manifold is a relatively large line, approximately 1¼ inches outside diameter, extending spanwise through the leading edge of the wing. A branch line extends to the tail. The air from the engine-driven pumps is first passed through one or more oil separators, then dumped directly into the pressure manifold. This manifold, being large, acts somewhat as an air reservoir from which the compressed air is admitted to the various tube groups as required.

(2) SUCTION MANIFOLD. The suction manifold is a relatively small

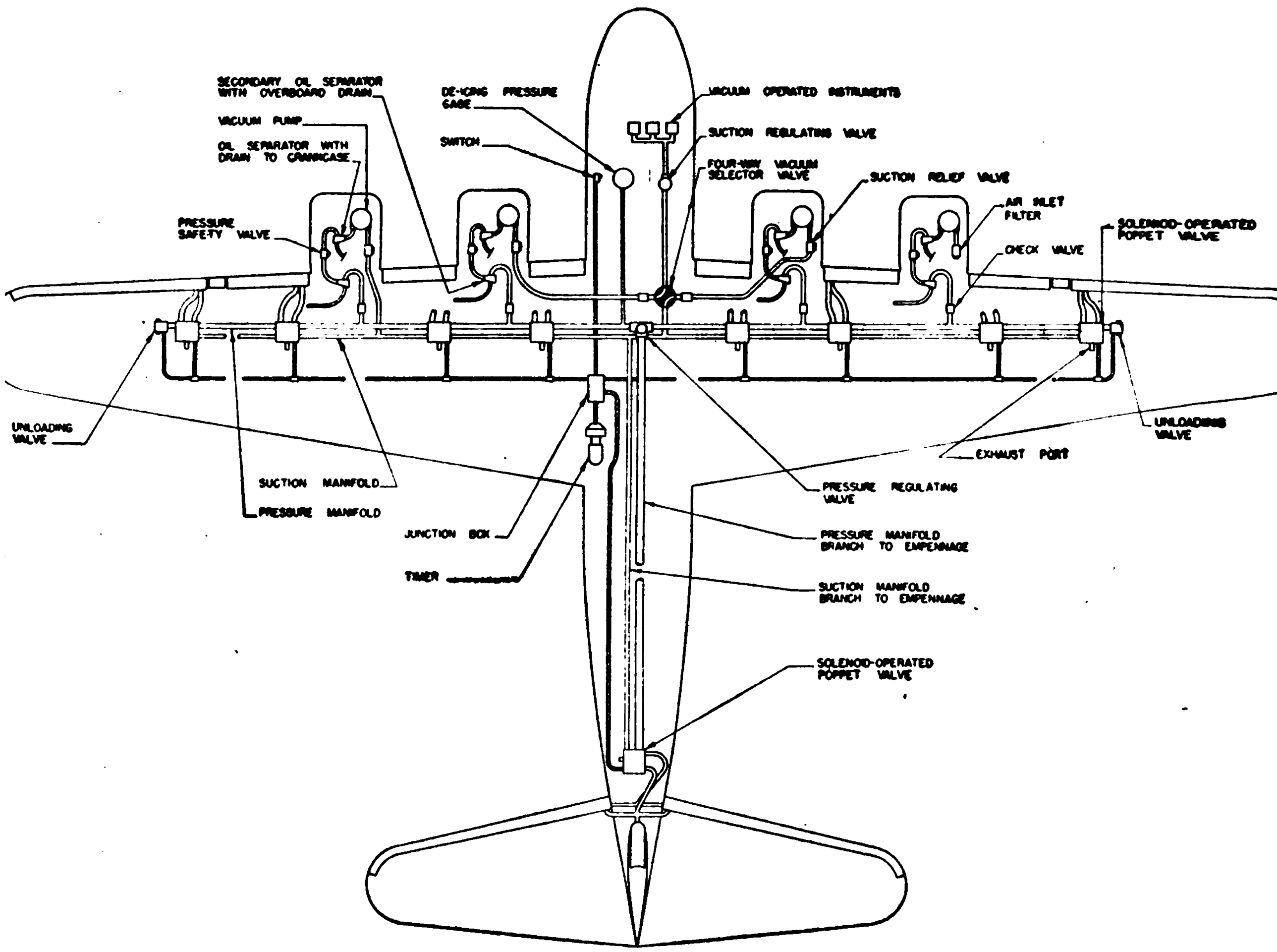


Figure 35. Typical manifold type de-icer piping system.

line, approximately ⅝-inch outside diameter. It parallels the pressure manifold line and also has a branch line to the tail. The suction manifold is connected to pump suction through one or more "tee" fittings.

(3) POPPET VALVES. The various de-icer tube groups are inflated and deflated by means of electrically operated poppet valves. Usually eight of these valves, spaced at convenient intervals, are provided in the leading edge of the wing. When installed, the poppet valve units support and form an integral part of both the pressure and suction manifolds. One poppet valve is located in the tail and terminates the manifold branch lines. Usually, each poppet valve in the wing operates only its adjacent de-icer shoe. The poppet valve in the tail operates all of the empennage de-icers. Operation is based on a 40-second cycle consisting of three phases—inflation, deflation, and suction. During the inflation phase, air from the pressure manifold flows into the de-icer tubes. During the deflation phase, the air in the tubes is exhausted to the atmosphere. During the suction phase, the de-icer tubes are connected to the suction manifold. Also, during flight with the de-icing system inoperative, all of the de-icer tubes are connected to the suction manifold.

(4) TIMER. The electric timer controls and coordinates the operation of the poppet valves. The timer is driven by an electric motor and is, in turn, controlled by an ON-OFF switch, usually located at the flight engineer's station. The contact segments of the timer correspond to the inflation tube groups. These segments are wired to the electrically operated poppet valves in such a manner as to inflate the tube groups in a predetermined periodic sequence. As with other de-icer piping systems, the operation of the shoes on the left and right wings is symmetrical. Some tube groups, being large, require more time to inflate fully than others. The duration of the inflation phase for a given tube group is proportional to the length of the corresponding contact segment. In order to prevent wastage of air, the contact segments are made proportional to the air requirements of their corresponding tube groups. Thus, since timer heads are designed for specific types of airplanes, the heads are not interchangeable between airplanes of different types.

(5) PRESSURE-REGULATING VALVE. The pressure-regulating valve is placed in the pressure manifold near the center of the airplane. It is usually adjusted to hold the system pressure at 8 pounds per square inch. The valve housing resembles a "tee" fitting and actually serves as such, since the side branch port is used to connect the tail branch of the pressure manifold to the spanwise manifold.

(6) UNLOADING VALVES. Two solenoid-operated unloading valves are provided, one mounted at each end of the spanwise pressure manifold. When the de-icing system is not being used during flight, air from the pumps flows into the pressure manifolds and toward the wing tips and is discharged to atmosphere by the unloading valves. When the de-icing system is put into operation, the unloading valves close automatically, since they are wired to the same ON-OFF switch used for starting and stopping the electric timer.

(7) TEST CONNECTION. A test connection is provided in the pressure manifold to facilitate ground tests.

21. OPERATIONS. When icing conditions are suspected, a close watch is kept of the leading edges of the airplane structure. If ice begins to form, the rate of formation on the de-icer shoes is observed as closely as possible. When a layer of ice at least ⅛ inch thick has formed, the de-icing system is turned on by means of the control handle or control switch, as the case may be, allowed to operate through one complete cycle, and then turned off. Successive layers of ice are removed by operating the system through one cycle at a time. The intervals between operations will depend on the rapidity with which the ice forms and the type of icing encountered. During severe icing conditions, continuous operation of the system may be necessary. On the other hand, under very light icing conditions, it may prove best to leave the de-icing system inoperative. In such cases, inflating the shoes might merely craze the thin layer of ice without causing it to be

removed. The crazing of the ice roughens the surface, increases the drag, and, if the rate of icing should become severe, might make subsequent de-icing difficult. Since icing conditions vary greatly, exact rules for operating inflatable-shoe systems cannot be set forth. Maximum effectiveness is obtained through experience and the exercise of good judgment. If there are residual ice formations clinging to the wing or empennage at the termination of a flight, the approach and landing should be made at somewhat above normal speed. This is done to prevent stalling or loss of control due to possible distortion of the air flow over the flight and control surfaces. The de-icing system should never be operated during take-offs. If a landing is made in icing conditions, the de-icing system should be turned off at about the time the engines are throttled for the final approach to the field.

22. INSTALLATION, REMOVAL, AND STORAGE OF DE-ICER SHOES. a. Installation. The procedure for installing de-icer shoes on different airplanes will differ slightly. The general procedure for installing de-icer shoes on the wings of an airplane is as follows:

(1) If the airplane has been in use without the shoes installed, remove the plugs or coverings from the connection holes in the leading edge of the wing.

(2) Remove the plug screws from the hollow threaded rivets. If any of the hollow rivets are damaged, drill them out with a No. 12 drill. Replace these with new ones, using a hollow rivet heading tool.

(3) If the leading edge has been camouflaged, the paint should be rubbed smooth with crocus cloth. Care must be taken not to scratch the wing skin.

(4) Apply strips of masking tape over laps in the wing skin, protruding rivet heads, and sharp edges which might damage the under sides of the de-icers or interfere with their operation. Also, apply masking tape over crevices, holes, and joints in the leading edge through which there is a possibility of air leaking to the under sides of the shoes, causing their upper stretch areas to lift from the wing skin.

(5) Locate and punch 1/8-inch-diameter holes in the upper and lower edges of the shoes, being careful not to nick the beadwires. In the case of the outermost shoes, where the ends of the de-icers must be curved around the wing tips, slide the edges of the shoes back along the beadwires to make the ends cup shaped. Do not locate or punch the holes in these portions until later.

(6) If new fairing strips are to be used, place the strips over the rows of hollow threaded rivets and spot the hole locations with an indexing tool. The holes should be spotted 5/16 inch aft of the forward edges of the strips. Drill lead holes through the strips, using a No. 28 drill. Machine countersink each hole 100° to accommodate the heads of the 6–32 attachment screws. The use of an adjustable stop type countersinking tool will facilitate this operation. Finish each hole by reaming with a No. 19 drill.

(7) Where the de-icers curve around the wing tips the standard 2-inch

fairing strip cannot be used. Cut curved fairing strips to suit from 53 S–T aluminum-alloy stock, 0.050 inch thick. Drill and countersink the holes in the same way as for the straight portions. With a mallet, pound a slight camber into fairing strip, using the standard fairing strip camber as a guide. Grind a bevel about ¾ inch wide under the rear edge of each curved strip. The thickness of the strip at the rear edge should be approximately 0.010 inch.

(8) Cut end clamps and clamp rings from 53 S–T aluminum-alloy flat stock, 0.050 inch thick and approximately 1 inch wide. When locating holes prior to drilling, allow for the thickness of the de-icer shoe.

(9) Brush a mixture of talc and unleaded gasoline on the leading edge. Allow to dry thoroughly before installing the de-icers. Also, dust the under sides of the de-icers with talc to provide lubrication.

(10) Apply adhesive tape to the under side of each fairing strip so that the tape extends out slightly from beneath the rear edge. This excess tape can then be trimmed off, if desired, so that the edge of the tape coincides with the rear edge of the fairing strip. The tape acts as a pad and prevents chafing and marring of the wing skin.

(11) Insert de-icer positioning pegs, small end first, in the upper row of hollow rivets. (Studs or headless screws are sometimes used instead of pegs.) Set the upper edge of each shoe into place so that the pegs or studs project through the punched holes. Allow the shoe to hang over the leading edge.

(12) If the shoe has a snubber, draw the edge of the snubber down to the row of hollow rivets to which it is to be attached. Spot the hole locations along the center of the flat metal head built into the edge of the snubber. These holes should be punched 9/64 inch in diameter, removing the shoe temporarily, if necessary.

(13) Lay the upper fairing strip into place over the pegs. Remove the pegs one by one and replace with 6–32 by ½-inch steel screws having 100° countersunk heads. Drive the screws in snugly but do not tighten until later. A screw driver bit, with a 3/16-inch diameter blade, mounted in the chuck of a high-speed hand drill will facilitate the work.

(14) Draw the nonkink hose ends through the holes in the leading edge. Connect these ends to the corresponding de-icer tube air stems, using special hose clips or friction-tape wrapping and safety wire. (See fig. 31.) Push the connections into place in the rubber grommets.

(15) Fasten the edge of the snubber, if used, to the row of hollow rivets provided, using round-head 6–32 by ½-inch steel screws. Cover the screw heads with masking tape to prevent damage to the under side of the shoe.

(16) Starting near the air-hose connections, draw the lower edge of the de-icer into position by means of a de-icer tensioning tool. Insert positioning pegs through the holes in the lower edge of the shoe and on into the bottom row of hollow rivets. (See fig. 36.) The use of a peg holder will

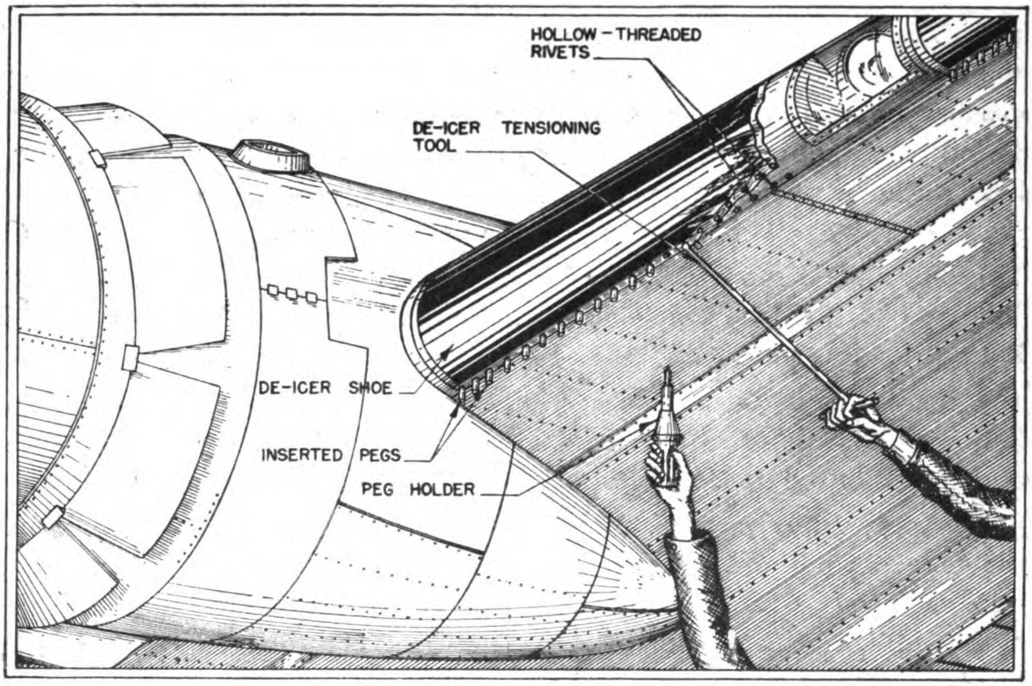


Figure 36. Tensioning a de-icer shoe.

greatly facilitate the insertion of the pegs. When the lower edge of the shoe has been pegged, place the lower fairing strip into position. Remove every other peg and replace with attachment screws. Then remove the remaining pegs and replace with attachment screws. Drive the screws until tight. The attachment screws in the upper row should now be tightened.
(17) If the shoe has a curved tip, locate and punch the holes progressively around the tip portion. Draw the end portion into position and insert pegs. Set the curved fairing strips in place. Replace the pegs with attachment screws, following the same general procedure as for the straight section.
(18) Install the end clamps and clamp rings, if any. Do not overlap the end clamps and fairing strips. Trim the ends of the shoes where they extend under the end clamps, taking extreme care to prevent scratching the wing skin. Also, cut off the ends of the beadwires to suit. Cut and trim openings in the shoe where necessary.
(19) If the upper and lower edges of the de-icer are provided with thin rubber flaps, these are smoothly cemented to the fairing strips. If suitable cements are not available or if the edge of the flap has been damaged, the flap should be trimmed to a width of approximately 3/8 inch, and then tucked under the forward edge of the fairing strip prior to driving in the attachment screws.
(20) Check the installation by operating the de-icing system. If the engines cannot be run up, connect the system to an external supply of compressed air. Check the sequence of tube inflations. Observe the

operation of each shoe closely for evidences of malfunction such as leaks, looseness, and unscheduled inflation of the tubes.

b. Removal. In removing de-icer shoes the procedure is as follows:
(1) Secure de-icer control handle to the OFF position by means of safety wire.

(2) Remove clamp rings and end clamps, tagging each part to identify it for future use.

(3) If cemented flaps are used, these can be loosened by means of high-test gasoline or benzol, used sparingly. Do not allow gasoline to come in contact with the de-icer shoes any more than absolutely necessary. Wipe the rubber dry as soon as possible.

(4) Remove the attachment screws and fairing strips, tagging the latter.

(5) Disconnect the hoses and remove the de-icers from the airplane. Lay the shoes on paper or on a bench. Avoid laying the shoes on gritty floors, or any place where they may come in contact with puddles of oil or gasoline.

(6) Place plugs in the ends of the nonkink hose. Some plugs are made to fit into the rubber grommets in the leading edge. These plugs have dummy metal stems, 5/8-inch outside diameter, over which the hose ends can be slipped. Fasten the hose ends to these metal stems using friction tape and safety wire, or special hose clips. Then, push these plugs snugly into the grommets so that the outer surface of each is flush with the wing skin. Where the grommets, or leading-edge seals, do not accommodate such hose plugs, tape over the hose ends and push these into the leading-edge structure. If possible, secure them inside the wing with safety wire or tape. If suitable rubber plugs for closing the holes in the leading edge are not available, cover the holes with doped fabric. On some airplanes removable cover plates are provided for this purpose.

(7) Fill all hollow threaded rivets with 6–32 by 3/8-inch plug screws. Any missing, damaged, worn, or loose hollow rivets should be replaced at this time.

(8) Remove masking tapes from the wing and tail leading edges.

(9) Wash off the talc used as a lubricant. Inspect the skin on the leading edge for evidences of corrosion.

(10) Apply camouflage paint to the leading edge if necessary.

c. Storage. The procedure for preparing de-icer shoes for storage is as follows:

(1) Clean each de-icer shoe thoroughly with soap and water.

(2) If the de-icer has thin rubber flaps at its edges, they should be cleaned with high-test gas or benzol to remove residual rubber cement from the under sides. Scrub them lightly and dry as soon as possible.

(3) Inspect the de-icers carefully. Stretching the rubber will help to locate small holes. If damage is discovered, mark the area with a crayon and turn in to a rubber shop for repair.

(4) Dust the under side of the shoe with talc.

(5) Wrap the ends of the beadwires and the metal air stems with masking tape to prevent chafing of the rubber.

(6) Starting at the end having the metal air connections, roll the de-icer into a coil. The inside diameter of the coil should be approximately 5 inches in diameter. Be sure the shoe is not wrinkled.

(7) Tail de-icers having a single exterior connection tube are rolled from the tip end.

(8) Wrap each rolled de-icer in heavy paper. Do not use safety wire, since this is likely to cut into the rubber. Label each roll carefully, indicating the serial number of the airplane from which the shoe was removed and its position on the airplane.

(9) Put the complete set for each airplane in an individual carton. Mark the carton with the airplane's type and serial number. Indicate the date of removal and shortages, if any.

(10) Finally, place the carton in storage in a cool, da k, dry place.

23. INSPECTION AND MAINTENANCE. a. Preflight check. The de-icing system is operated during engine warm-up, prior to take-off, whenever there is even a remote possibility of encountering icing conditions during the flight. The de-icer pressure gauge and the suction gauge are checked with the vacuum selector valve in each of its alternate positions in order to make sure that the pumps are functioning properly. The shoes are checked to make sure that all of the tubes are inflating and deflating. The de-icing system is turned off before take-off.

b. 25-hour ground check. The de-icing system is inspected and operated at each 25-hour check. If, for some reason, the engines cannot be operated, the system is connected to an external supply of compressed air, using the test connection provided for this purpose. Air introduced into the system should not exceed 10 pounds per square inch gauge pressure. As the air is introduced, an observer should be stationed in the cockpit to watch the vacuum-operated flight instruments. If any of these begin to operate, it indicates that one or more of the check valves has failed to close and that reverse flow through the instruments is occurring. Shut off the air immediately, and remedy the difficulty before proceeding further with the ground test. If the check valves are satisfactory, turn on the de-icing system and check the following:

(1) CONTROL HANDLE OR SWITCH. Check the ON-OFF control for freedom of movement.

(2) PERIOD OF OPERATING CYCLE. The time required for the distributor valve or electric timer to complete one cycle should be not less than 35 seconds or more than 45 seconds. If the time is longer or shorter, check the voltage applied to the electric motor. If the voltage is correct, check the brushes for wear. In very cold weather allow the de-icing system to warm up for approximately 15 minutes before checking the period of operation.

(3) DE-ICING PRESSURE GAUGE. During operation, the pointer should fluctuate between 7 and 9 pounds per square inch gauge pressure. Adjust the pressure-regulating valve if necessary.

(4) SEQUENCE OF INFLATION. If new or replacement de-icer shoes have been installed, the sequence of inflation of the tube groups should be checked to make sure that the air connection stems have been properly connected.

(5) OIL IN THE SYSTEM. Disconnect all drain lines and check for proper drainage. In cold weather extreme care must be taken to see that oil does not collect and congeal in the system.

(6) INSPECTION OF DE-ICER SHOES. While operating the system, observe each shoe closely for evidences of malfunctioning. After turning off the system, inspect the exterior surfaces for cuts, tears, bruises, and abraded areas. Check the tightness of the attachment screws.

c. 100-hour ground check. At each 100-hour inspection of the airplane, all of the items listed for the 25-hour inspection are checked. In addition, the filter element in the secondary oil separator is removed and washed in gasoline, allowed to dry, and then replaced in the chamber.

d. Resurfacing de-icers. When the outer surface of a de-icer shoe has become worn, badly scuffed, or bruised, its conductivity is destroyed. This permits electrostatic charges to build up on the leading edge during flight. Sometimes these charges will arc through the shoe to the wing skin, causing punctures in the fabric tubes. These electrostatic charges may also constitute a temporary fire hazard after the airplane has landed. To prevent these troubles, the de-icer is sprayed with conductive cement whenever signs of considerable wear or abrasion are noted. The procedure for resurfacing de-icers is as follows:

(1) During cold weather the airplane should be placed in a heated hangar and so located that the de-icers are in line with one or more hot-air blast heaters. The resurfacing should be done before any other work called for on the airplane is done in order to allow as much time as possible for the new surface to cure.

(2) Scrub the de-icer surface with a clean cloth, moistened in isopropyl acetate or benzol. If necessary, use a vigorous scrubbing action to remove all loose particles and to smooth out any wrinkles in the old coating.

(3) With masking tape, mask off all exposed metal surfaces around the edges of the shoe, clamp rings, wing lights, etc. Also, mask the manufacturer's label so that the de-icer can be identified later.

(4) Using standard spray equipment, spray a light coat of conductive cement on the shoe and allow it to dry thoroughly. Then spray on a second coat. The cement can be thinned with isopropyl acetate.

(5) One or more extra coats should be sprayed on wherever severe abrasion or scuffs are noted. Allow each coat to dry thoroughly.

(6) After the final spraying, remove the masking tape. If further work

is being done on the airplane, a placard should be hung on the leading edge with the following words: DE-ICERS SPRAYED—DO NOT TOUCH. The airplane should remain in a warm place as long as possible. An overhead blast heater or portable ground heater will speed up the curing.

e. Minor vulcanizing repair of de-icers. Small cuts, tears, and gouges in de-icer shoes are repaired by means of a portable vulcanizer. The procedure is as follows:

(1) Clean the damaged area thoroughly, using soap and water or high-test gasoline. If gasoline is used, apply sparingly and wipe dry immediately to prevent damage to the rubber.

(2) Buff the area to be patched, using a carborundum stick or small wire brush. Buff an area somewhat larger than the patch to be applied, since the repair gum will flow slightly during the vulcanizing process.

(3) Prepare a small batch of de-icer vulcanizing cement by mixing equal parts of de-icer vulcanizing cement and accelerator. A small paper cup can be used for this purpose.

(4) For a small tear, cut a suitable patch, round or elliptical in shape, from a sheet of 0.020-inch-thick uncured repair gum. The patch should be smaller than the area of the vulcanizer platen to allow for flow of the repair material during vulcanization.

(5) Remove the de-icer attachment screws along the edge of the shoe in the vicinity of the damage. A sufficient number of screws should be removed to permit the beaded edge of the de-icer to be pulled readily from under the leading edge of the fairing strip.

(6) Before putting the vulcanizer in place, turn the tightening-screw wing nut so that the platen is at the same position as when at its maximum height above the pad. Then slip the pad portion of the tool under the loose edge of the de-icer. Locate the pad under the damaged area.

(7) Using a small brush, paint the damaged area with the previously prepared vulcanizing cement. Also paint the surrounding area, approximately an inch in each direction, to allow for the flow of the repair material. Allow the cement to dry.

(8) Wash the previously cut patch in benzol, allow it to dry, then lay it over the damaged area.

(9) Connect the vulcanizer platen to a source of 110-volt a-c electricity. Preheat the platen for 2 or 3 minutes. Then tighten the platen down against the patch. Apply heat and pressure for approximately 12 minutes. Remove the vulcanizer and allow the patch to cool.

(10) Replace the attachment screws.

(11) Lightly buff the patched area to remove the shine.

(12) Paint the patch and surrounding area with conducting cement and allow to dry.

(13) The procedure for repairing gouges in the shoe is the same as for tears, except that after brushing on the vulcanizing cement, cut small slivers

of repair gum and press these into the depression to serve as a filler. Then brush a coating of vulcanizing cement over the gum packing and allow it to dry before applying the final patch. Vulcanize as previously described.

(14) To repair a small hole in the stretch area, clean and buff the edges of the hole as well as the surrounding area. Brush on a coat of vulcanizing cement and allow to dry. Cut a patch of uncured gum the exact shape of the hole. Wash in benzol and press into place to serve as a filler. Paint over with vulcanizing cement and allow to dry. Then lay the final patch in place over the buffed area and vulcanize as previously described.

(15) If the tears or gouges are too long to be repaired with one operation of the vulcanizer, a series of overlapping repairs can be made.

(16) When repairing a large break, apply a rectangular fabric patch to the underside of the shoe, in addition to the usual outside repair. Since de-icer repair fabric can be stretched in only one direction, it must be so placed that it will stretch in a chordwise direction. If the de-icer has a sponge rubber filler or backing, snip out a section of the sponge ply to the exact shape of the fabric patch. Buff the depression and surrounding area. Brush with vulcanizing cement and allow to dry. Lay the fabric into the depression. Paint over with vulcanizing cement and allow to dry. Cut a somewhat larger patch from gum sheet stock and lay over the fabric. Prepare the outside of the shoe in the usual manner, and vulcanize. Be careful not to vulcanize the underside of the repair to the rubber pad of the vulcanizer. This can be prevented by inserting a clean, thin piece of sheet steel or aluminum between the rubber pad and the underside of the shoe before vulcanizing. Such a shield, if used, should be about 5 or 6 inches square and should have rounded corners to reduce the risk of scoring the underside of the de-icer.

f. Major repair of de-icer shoes. When damage to a de-icer is extensive, particularly in the tube area, the shoe should be replaced. The damaged de-icer should then be turned over to a rubber repair shop for major repair.

g. Cold-patch repair of de-icers. Cold-patch repairs should be resorted to only in emergencies when time does not permit the use of a vulcanizer. All of the tools and materials for making cold patches are contained in a cold-patch de-icer repair kit. The procedure for repairs of this type is as follows:

(1) Clean and buff the damaged area.

(2) Brush a coat of cold-patch cement over the buffed area and allow to dry.

(3) Cut a suitable patch from cold-patch rubber-repair sheet, skiving or beveling the edges.

(4) Remove the cloth backing from the patch and lay the patch over the damaged area, taking care to avoid wrinkles.

(5) Using a metal roller, roll down the patch, particularly at the edges to insure a close bond.

(6) Coat the patch and surrounding area with conductive cement.

(7) If the tear is over 2 inches in length, a vulcanized repair should be made. However, if for some reason a vulcanized repair cannot be made, apply a fabric patch to the underside, snipping out a section of the sponge rubber ply, if necessary. In this case the fabric patch is attached by means of de-icer cold-patch cement, then rolled down firmly. A slightly larger patch of thin gum stock is then cemented over this and also rolled down firmly. Be sure each coat of cement is allowed to dry before applying the patch. The outside of the shoe is cold patched in the usual manner and coated with conductive cement.

h. General care of de-icer shoes. Because of their function, de-icer shoes are necessarily soft and pliable and, therefore, easily damaged through rough handling. Also, being mounted on the leading edges of the wing and tail, the de-icers are exposed to sunlight, rain, engine oil, propeller anti-icing fluid, exhaust gases, and the abrasive effect of dust and sand. To prolong the service life of a set of de-icer shoes, the following rules should be adhered to:

(1) When refueling the airplane, be very careful not to drag the gasoline hose over any of the de-icers. If the hose must be brought over a de-icer, a pad should be used to prevent bruising the shoe. Also, avoid spilling gasoline on the shoes. If gasoline is spilled on the shoes wipe them dry as quickly as possible.

(2) After each flight, wash off any engine oil or propeller anti-icing fluid which may have been thrown on the de-icers.

(3) Do not walk on the de-icers.

(4) Do not lay tools or pieces of cowling on the de-icers.

(5) Do not lean ladders or other maintenance equipment against the de-icers unless suitable padding is provided.

(6) Resurface the de-icers when the outer surfaces have become worn or abraded.

(7) Repair small holes, cuts, tears, and gouges promptly, to prevent further damage during flight.

(8) When removing shoes for storage, do not lay them on rough concrete, gravel, or any place where they may come in contact with pools of oil or gasoline. Removed shoes should be placed on wrapping paper, dry grass, canvas, or similar surface until further disposition is made.

SECTION VII
OXYGEN EQUIPMENT

24. GENERAL. a. Need for oxygen equipment. Oxygen is required by the body to maintain proper functioning of the nervous system and to prevent harm to the body cells. The body normally obtains this oxygen from the air. Because of the decreased density of the air at high altitudes, oxygen must be added to the air inhaled by personnel engaged in high altitude flying. At extremely high altitudes, pure oxygen is supplied.

b. Use of oxygen. Auxiliary oxygen must be used by all personnel on all flights above 10,000 feet and on all flights at night. The crew chief should keep these regulations in mind when determining the supply of oxygen necessary for a given flight.

c. Basic units. Auxiliary equipment is needed to supply the oxygen required by personnel flying at high altitudes. Any oxygen system will include the following basic units:

(1) A supply cylinder or tank.

(2) Tubing to connect the units to each other.

(3) A regulator.

(4) A mouthpiece or mask.

(5) A pressure gauge and flow indicator (incorporated in the regulator of a continuous-flow system).

25. OXYGEN CYLINDERS. a. High-pressure type. (1) A lightweight, seamless steel cylinder with a rounded base is used for storing high pressure oxygen. It is painted green and is equipped with a hand shut-off valve. Some high-pressure cylinders, known as the reinforced type, are wrapped with piano wire and dipped in solder to prevent shattering if struck by a bullet or shell fragment.

(2) High-pressure cylinders carried in aircraft are classified according to volume. The types are A–2, B–1, C–1, D–1, and E–1. The type E–1 is the largest.

(3) These cylinders are designed to store oxygen at a pressure of 1,800 pounds per square inch. In combat areas the storage pressure for the non-reinforced type has been reduced to 1,100 pounds per square inch.

(4) High-pressure cylinders are equipped with hand shut-off valves which may be of the single- or double-seat type. These valves should be kept closed unless oxygen is being used. They should be tightened only "finger-tight," as excessive tightening will cause them to seize. A safety disk and

a fusible metal plug are located in the valve. The safety disk will rupture and allow the gas to escape if the pressure within the cylinder becomes dangerously high. The fusible plug will melt and allow the gas to escape if the temperature reaches 212° F.

b. Low-pressure type. (1) this type is a lightweight, stainless steel cylinder made of two halves which are welded together. This type of cylinder is not equipped with a valve. If several cylinders are connected, a shut-off valve is usually installed in the line between them and the regulator. These cylinders can usually be charged without removing them from the airplane. Some are reinforced with metal strips which are welded to the cylinder.

(2) Low-pressure cylinders are classified according to size as A–4, D–2, F–1, and G–. The type G–1 is the largest size.

(3) These cylinders are designed to store oxygen at a pressure of 400 pounds per square inch. In combat zones this pressure is reduced to 300 pounds per square inch unless the reinforced type is used.

26. TUBING. a. Pressure tubing. Oxygen is conducted from the cylinder to the regulator by pressure tubing. This may be of copper or aluminum alloy. High-pressure systems usually have copper tubing which is silver-soldered to the fittings. Low-pressure systems have either aluminum alloy or copper tubing.

b. Flexible tubing. (1) Oxygen is conducted from the regulator or oxygen outlet to the mouthpiece or mask by flexible tubing. Tubing used with mouthpieces is made of rubber and may or may not be armored. It may be secured in standard 3- and 6-foot lengths. It is not to be cut. If the piece being used is too long, the surplus is coiled and taped to a structural part of the airplane.

(2) Low-pressure tubing for use with masks is usually a part of the mask. This tubing may or may not be equipped with a bayonet fitting.

27. OXYGEN REGULATORS. a. Purpose. A regulator is included in an oxygen system to reduce cylinder pressure and regulate the rate of flow of oxygen to the user.

b. Types. Two general types of regulators are in use; the continuous-flow type and the demand type.

(1) A continuous-flow regulator delivers oxygen to the user as long as the needle valve is open and the cylinder contains gas under pressure. It may be either a high-pressure type (fig. 37) or a low-pressure type (fig. 38). A schematic drawing of a continuous-flow regulator is shown in figure 39. Oxygen from the supply cylinder enters the back chamber through the regulating valve. As pressure increases in the back chamber, the diaphragm is moved to the left. This operates the toggle links and closes the regulating valve. When pressure in the back chamber decreases, the diaphragm and toggle links are moved to the right by the spring and the regulating valve

is opened. Oxygen passes through a manually controlled needle valve and an orifice to the mouthpiece or mask. One of the Bourdon tube mecha-

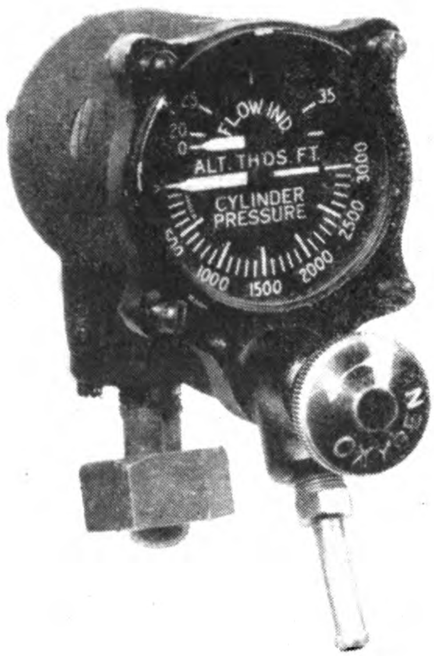


Figure 37. High-pressure continuous-flow oxygen regulator.

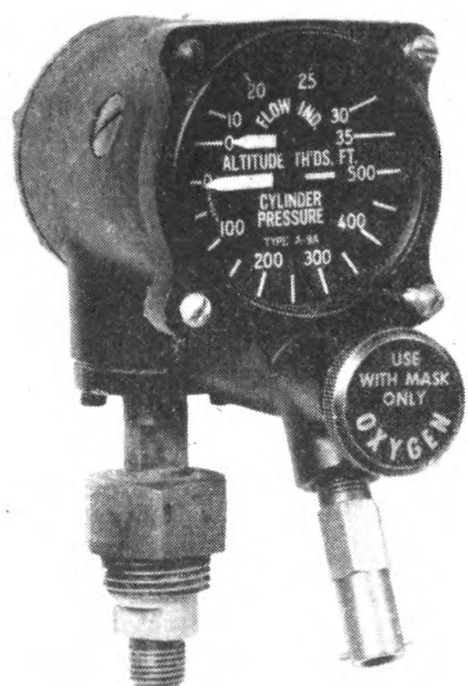


Figure 38. Low-pressure continuous-flow oxygen regulator.

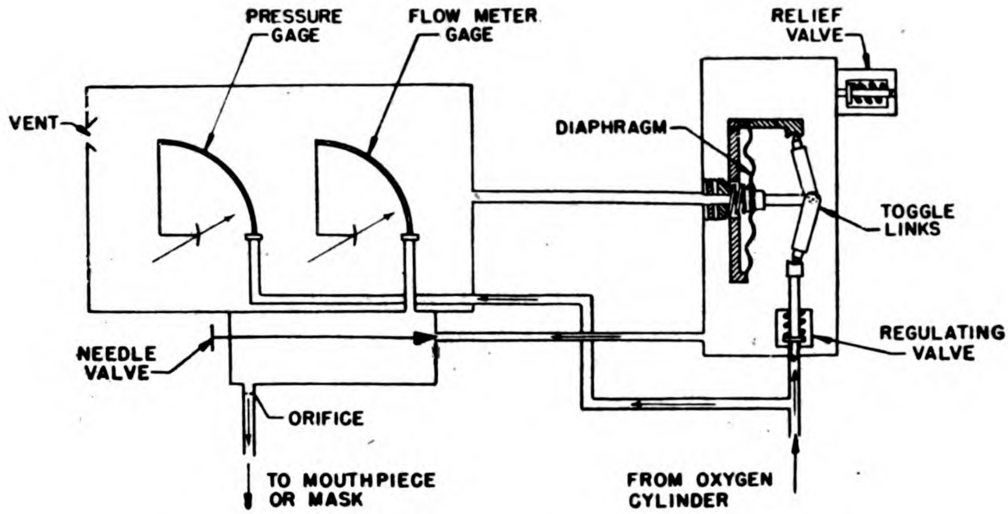


Figure 39. Schematic drawing—continuous-flow oxygen regulator.

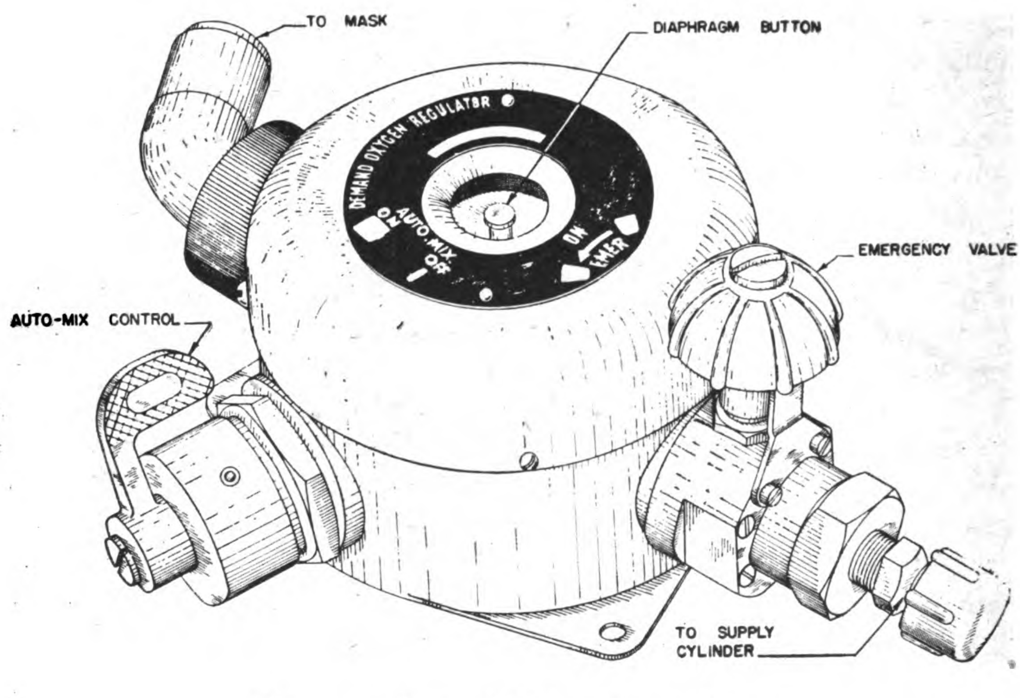


Figure 40. Demand type oxygen regulator.

nisms indicates the pressure in the supply cylinder. The other indicates the flow of oxygen to the user. This indicator is calibrated in terms of altitude. A relief valve is located on the back chamber. This relief valve is adjusted by the manufacturer and its setting is not to be changed.

(2) A demand type regulator, figure 40, delivers oxygen only when needed

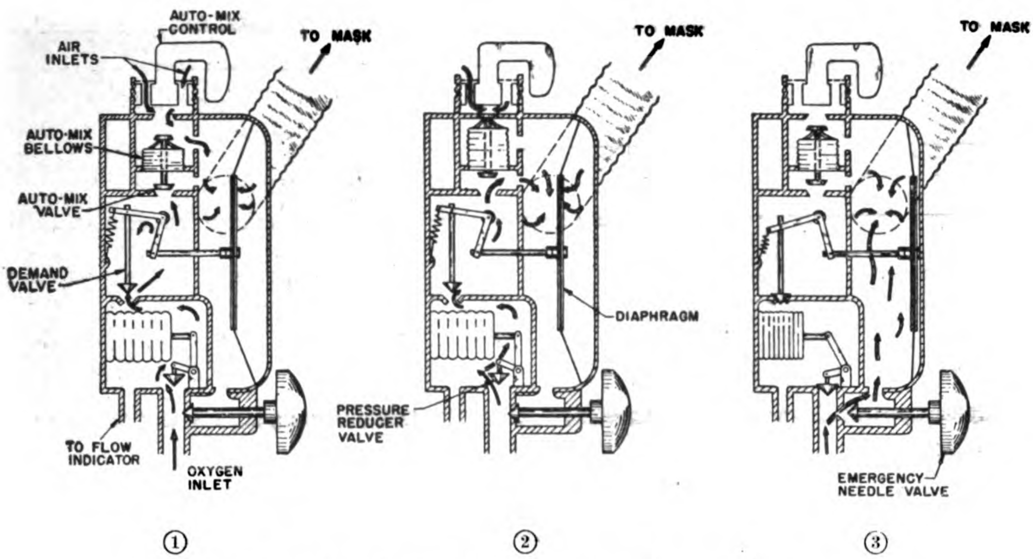
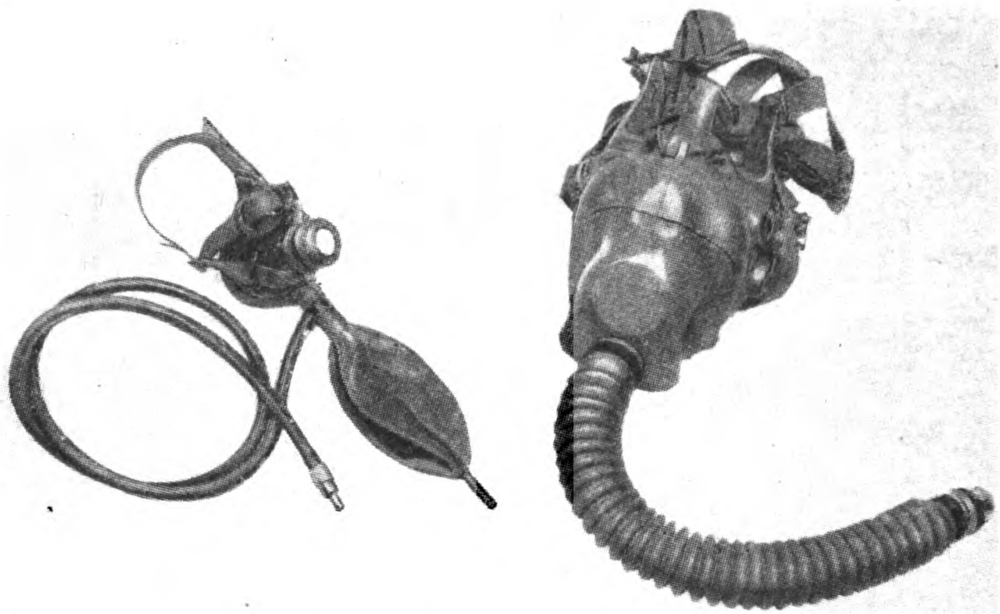


Figure 41. Schematic drawing—demand type oxygen regulator.

and in the quantity needed. It automatically compensates for altitude when the auto-mix control is ON. At or near sea level the auto-mix bellows will be almost completely depressed by atmospheric pressure as shown in figure 41①. When the user inhales, the diaphragm moves toward the left and opens the demand valve. A small amount of oxygen can flow past the auto-mix valve and mix with the incoming air which goes to the mask. When the user exhales, the diaphragm moves to the right, closes the demand valve, and stops the flow of oxygen through the unit. At very high altitudes, atmospheric pressure will be much lower. The auto-mix bellows will therefore assume the position shown in figure 41②. No air can enter the unit as the opening is closed. The bottom opening of the auto-mix valve is open, so oxygen can flow freely through the unit and out to the mask. At any intermediate altitude, the auto-mix valve will be moved by the bellows to a position which will allow the correct mixture of oxygen and air to flow to the mask. A needle valve is incorporated in the unit for emergency operation. If the regulator fails to function properly, this valve is opened and oxygen is fed directly into the main chamber and to the mask as shown in figure 41③. Demand regulators are used in either high- or low-pressure systems. If used in a high-pressure system, a pressure reduction valve must be installed in the line from the cylinder to reduce the pressure reaching the regulator to not over 500 pounds per square inch.

28. MOUTHPIECES AND MASKS. a. Mouthpieces. The oxygen mouthpiece is a short rubber or composition pipestem or nipple. It is very inefficient and is being replaced by the mask.

b. Masks. Several types of masks are used by the Army Air Forces. Two types are shown in figure 42. All types except the A–8B and the A–10 will be discontinued as soon as the present supply is exhausted.



① *For use with continuous-flow regulator.*

② *For use with demand regulator.*

Figure 42. Oxygen masks.

(1) The A–8A mask is designed for use in a continuous-flow system. It may be used in either a high- or a low-pressure system. It consists essentially of the mask proper, flexible tubing, a sponge rubber outlet, a rebreather bag, and attaching harness.

(2) The A–8B mask is an improved design which is very similar to the A–8A. Provision is made for the installation of a microphone in a turret in the mask. This type does not have an attaching harness but is fastened to the helmet with straps.

(3) The A–10 mask is designed for use in a demand type system and can be used only with a demand type regulator. It consists of the mask proper, a corrugated rubber inlet tube, and attaching harness. Oxygen from the inlet tube enters the mask proper through two openings at nose level. A housing for microphone mounting is provided in the front of the mask. The opening from this housing is closed by a rubber plug when no microphone is used. When the wearer exhales, a rubber check valve allows the CO_2 to go out of the mask through an opening in the bottom of the mask. During inhalation this valve closes and prevents the outside air from entering the mask.

29. TYPES OF SYSTEMS. a. General. (1) Installations, even of the same type system, will vary widely in different airplanes. The ones described in this paragraph are general and not particular installations.

(2) Oxygen systems may be classified as continuous-flow type and demand type.

b. Continuous-flow type. The continuous-flow system is one containing a continuous-flow regulator. The basic units are one or more supply cylinders, a continuous-flow regulator, a mouthpiece or mask, and connecting tubing. A pressure gauge and flow indicator are integral with the regulator.

(1) A high-pressure continuous-flow system includes one or more high-pressure cylinders and an A–6, A–8, or A–8A regulator. A system of this type is shown in figure 43. Oxygen flows continuously to the mouthpiece

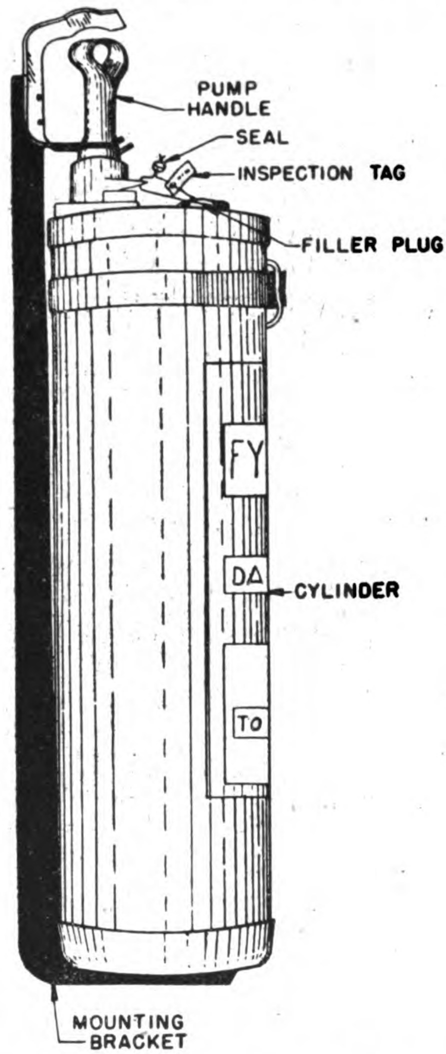


Figure 43. High-pressure continuous-flow oxygen system.

or mask when the needle valve of the regulator is opened. In this system the cylinders must be removed from the airplane for recharging.

(2) A low-pressure continuous-flow system includes one or more low-pressure cylinders and one or more A–9 or A–9A regulators. The needle valve of the regulator is operated manually to secure the desired flow of oxygen to the mask. This flow is continuous as long as the needle valve is open. If several cylinders are used, they are connected together in the airplane, and

may be filled through a filler valve. (See par. 31.) A regulator is located at each station. Check valves are installed to prevent failure of the entire system if one part should fail. A system of this type is shown in figure 44.

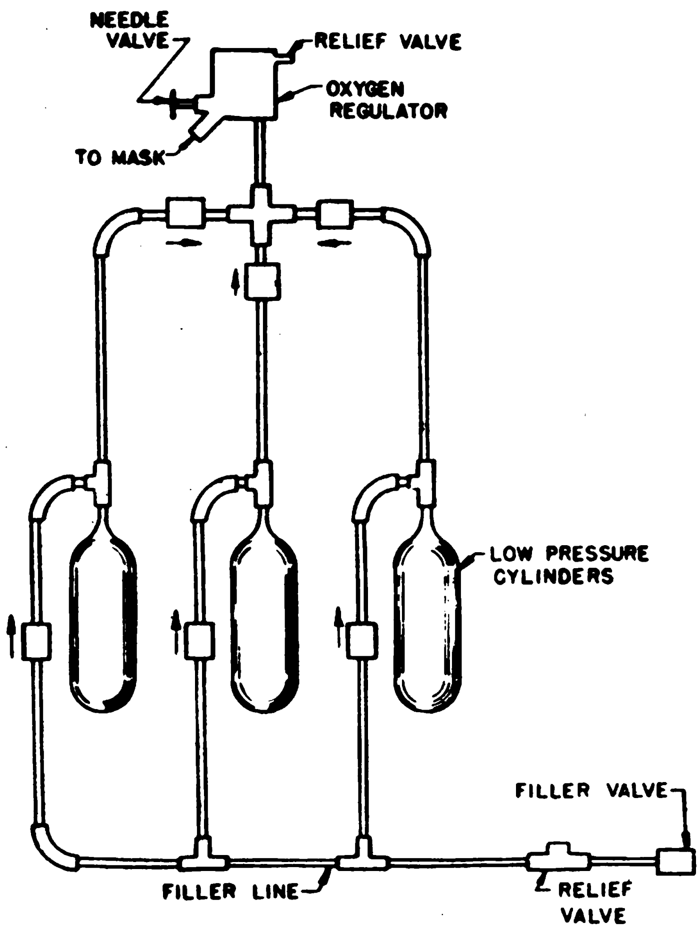


Figure 44. Low-pressure continuous-flow oxygen system.

(3) The type A-11 low-pressure continuous-flow regulator supplies oxygen to a maximum of 15 outlets. It is used in cargo aircraft for use in transporting troops. The regulator automatically varies the flow of oxygen as the altitude increases.

c. Demand type. (1) The low-pressure demand system is one containing a demand regulator. Since this regulator does not have a pressure gauge and flow indicator, these units are usually mounted on a panel. The standard panel also includes a supply warning light. If an A-3 flow indicator is used, it is connected *only* to the regulator. Other indicators are installed in the supply line.

(2) A low-pressure demand system includes an A-12 regulator at each station. This system does not contain a pressure-reducing valve, as this unit is not needed. The cylinders are recharged through the filler valve. A system of this type is shown in figure 45.

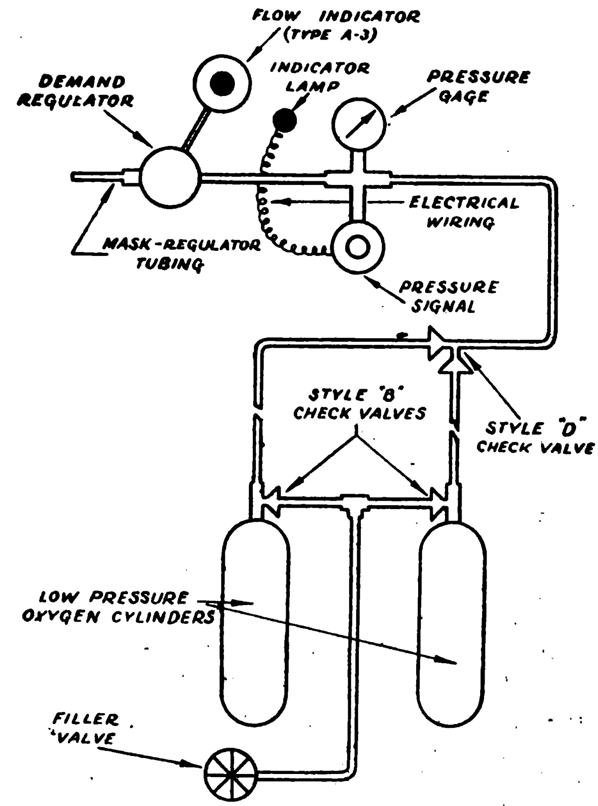


Figure 45. Low-pressure demand type oxygen system. Low-pressure oxygen symbols used: Specification 40363B.

30. PORTABLE EQUIPMENT. a. Purpose. This equipment is used to supply oxygen to personnel who are not supplied by the airplane system, who must move about in the airplane, or who must "bail out" at high altitudes.

b. High-pressure types. (1) Two types of high-pressure portable apparatus are in use. They differ only in the kind of cylinder used.

(2) High-pressure portable equipment consists of a high-pressure cylinder to which a type A–8 regulator is attached. It is carried in a cloth bag which is slung around the neck. Recharging is by the equalizer manifold method.

c. Low-pressure type. Low-pressure portable equipment consists of a low-pressure cylinder to which an A–13 demand regulator is attached. A clothing clip is provided for carrying the equipment. A recharging nipple is installed in the regulator. This permits recharging from the airplane demand oxygen system while in flight.

d. "Bail-out" type. "Bail-out" equipment consists of a small high-pressure cylinder, a hand-operated valve, and tubing with a pipestem mouthpiece. The valve is metered to give the proper flow when fully opened.

31. RECHARGING OXYGEN CYLINDERS. a. General. The cylinders

of some oxygen systems must be removed from the airplane for recharging. In other systems, the cylinder may be recharged, without removal, through a filler valve. Technical Orders should be consulted for the method to be used on any particular installation.

b. An equalizer manifold is used to recharge high-pressure cylinders which must be removed from the airplane for this service. As the heat generated will prevent transfer of a full charge of gas to the cylinders, they are cooled by placing them in water during charging. The procedure for recharging is as follows:

(1) Connect the cylinders to be charged to the manifold as shown in figure 46.

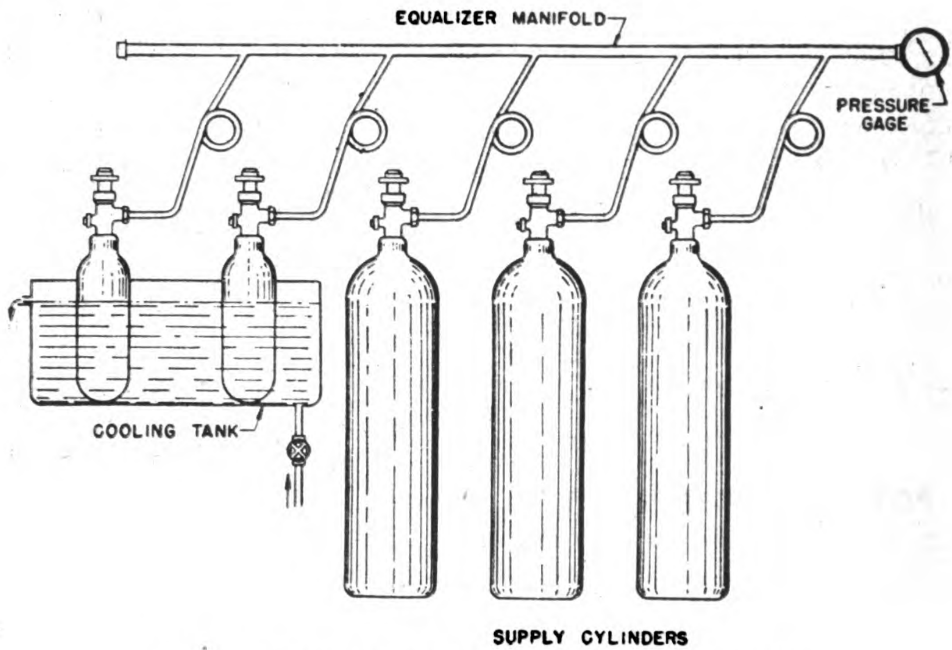


Figure 46. Recharging high-pressure oxygen cylinders.

(2) Slowly open the valves on the cylinders to be charged to allow any partial charge of gas to equalize between them.

(3) Slowly open the valve on the supply cylinder having the lowest charge (marked on the side of the cylinder) and allow the pressure to equalize. Mark this pressure on the side of the supply cylinder.

(4) Close the valve on the supply cylinder and slowly open the valve on the supply cylinder having the next higher pressure and allow the pressure to equalize. Mark this pressure on the side of this supply cylinder.

(5) Proceed in this manner, using supply cylinders with progressively higher pressures until the desired pressure is obtained in the cylinders being charged. From 1,600 to 1,700 pounds per square inch is the maximum which may be obtained without excessive changing of cylinders.

(6) Close all valves and remove the charged cylinders. Check for leakage by submerging the valve in water.

c. To service low-pressure oxygen cylinders without removing them from the airplane, a portable recharger is used. This unit consists of a cart on which the supply cylinders, gauges, pressure regulator, purifier, and connecting tubing are mounted. A length of flexible hose with a shut-off valve and filler adapter is used to make the connection to the airplane. To charge the cylinders, proceed as follows:

(1) Make sure that the pressure regulator is closed, then open the cylinder valve on one supply cylinder.

(2) Insert the adapter end of the hose into the filler valve in the airplane. Push the adapter in until it snaps in place.

(3) Open the shut-off valve on the end of the filler hose.

(4) Slowly increase the pressure by opening the pressure regulator.

(5) When the regulator gauge gives a constant reading approximately 25 pounds per square inch above the desired pressure, close the regulator. Close the shut-off valve and disconnect the filler hose by turning the outer collar one-eighth of a turn. Hold the end of the tube securely, as pressure will blow the adapter out of the valve.

d. An oxygen servicing trailer is used to recharge high-pressure oxygen cylinders without removing them from the airplane. This assembly may also be used to recharge low-pressure oxygen cylinders. It consists of 14 high-pressure cylinders, purifiers, connecting tubing, and a control panel mounted on a trailer. A flexible hose is provided for connection to the oxygen system on the airplane. To recharge high-pressure cylinders, proceed as follows:

(1) Set the regulator so that the "delivered pressure setting" gauge registers the pressure to be delivered to the airplane.

(2) Connect the adapter end of the hose to the filler valve on the airplane. The adapter must be securely tightened.

(3) Open the filler valve on the airplane, then open the filler valve on the end of the hose.

(4) Open valve 1 on the control panel and allow the pressure to equalize. Note the pressure on the "delivered oxygen pressure" gauge on the control panel. If this is less than the required pressure, close valve 1 and open valve 2. Continue this procedure until the cylinders have been charged to the desired pressure. Close the valve on the control panel which was last used.

(5) Close the filler valve on the airplane and the one on the end of the hose. Disconnect the filler hose.

(6) Open the valve on the end of the hose long enough to allow pressure to escape.

32. INSPECTION AND MAINTENANCE. a. Preflight inspection. Prior to each flight on which oxygen is to be used, the following inspections will be made:

(1) Check equipment for completeness and general condition.

(2) Visually check all lines for damage. Replace damaged lines.
(3) Determine whether sufficient oxygen is contained in the system for the intended mission. If information concerning the mission is not available to the crew chief, the system will be filled to maximum capacity. The charge of gas in continuous-flow systems is checked by fully opening the cylinder valves when the regulators are shut off. If the system is fully charged, the pressure gauge will show 1,800 pounds per square inch (1,100 pounds per square inch for nonreinforced cylinders on airplanes in combat areas) for a high-pressure system and 400 pounds per square inch (300 pounds per square inch for nonreinforced cylinders on airplanes in combat areas) for low-pressure systems. The state of charge is directly proportional to this pressure. In the checking of any low-pressure system, the pressure must be checked at each station.
(4) High-pressure continuous-flow systems are checked for leaks by closing the cylinder valve and then noting whether or not there is any drop in pressure. If a noticeable drop occurs, locate the leak by using a solution of castile soap and water. All leaks should be repaired before flight.
(5) Continuous-flow indicators are checked for operation by completely opening the needle valve. A properly working instrument should give a flow indication of 35 if cylinder pressure is above the minimum allowable pressure for the cylinder.
(6) To check the demand regulator for operation, close the air valve and depress the diaphragm button, which is accessible through the hole in the cover. A noticeable stream of oxygen should pass through the elbow. Release the button and open the emergency valve to be sure it is in operating condition.
(7) If the cylinder valve (in a high-pressure continuous-flow system) is not easily accessible to the pilot, it should be opened before take-off and closed as soon as possible after landing.

b. Fifty-hour inspection. At each 50-hour inspection the date of the last hydrostatic test should be checked. This date is stamped on the upper shoulder of the cylinder. If cylinders are found that require this test in 3 months or less, they will be removed and replaced. Hydrostatic tests are not applicable to low-pressure cylinders.

c. Maintenance. (1) All oxygen equipment should be kept clean. *Do not use oil or grease* in any form on oxygen equipment. A mixture of yellow lead oxide (litharge) and glycerin may be used as a sealing compound.
(2) Oxygen cylinders may be sprayed or painted with the proper material. Cylinders should be handled carefully to prevent denting. Denting will cause the cylinder to lose some of its strength and may result in an explosion.
(3) Defective indicating instruments will be returned to instrument repair departments of control depots where the maintenance will be accomplished in accordance with the latest instructions.

(4) After each flight on which it is used, the mouthpiece is sterilized by soaking it for 5 minutes in a 5 percent solution of cresol and then rinsing it. After the last flight of the day all masks which have been used will be cleaned by thoroughly washing all parts (except the sponge rubber disk of the type A–8 series masks) in a lather made from a good quality facial soap and warm water. In the case of type A–8 series masks, the sponge rubber disk is first removed and washed in *clean* water only. After washing, the mask should be thoroughly rinsed with clean warm water and dried. Masks should be handled carefully and should not be exposed to sunlight and heat any more than is necessary.

SECTION VIII
HEATING AND VENTILATING EQUIPMENT

33. GENERAL. a. Purpose and use. Heating and ventilating systems provide for the circulation of the proper amount of fresh air heated to the correct temperature during the time that the aircraft is in operation. The actual use of these systems in aircraft depends largely upon the type of airplane that is to be heated. Most smaller airplanes use the simpler manifold heater in which the air is heated at the exhaust manifold and conducted to the cockpit. Many larger airplanes—bombers, transports, etc.—employ more elaborate heating systems in which steam or glycol is used to transfer the heat from the exhaust stack to the radiator. Here the heat is transferred to air which is conducted to the various compartments of the airplane. The combustion heater is more flexible and is used on any type of airplane either as a single unit or as a combination of units.

b. Classification. Heating systems may be classified according to the method used to generate heat and transfer it to the air that is used for heating. For this reason, aircraft heaters have been classified in this text as manifold heaters, steam heaters, glycol heaters, and combustion heaters.

34. HOT-AIR HEATERS. a. Manifold heaters. Manifold heaters provide a simple system of heating. Hot air may be taken from a shell that is mounted about the exhaust manifold of the airplane. This air is led through a conductor tube and admitted to the cockpit of the airplane. By means of valves the pilot controls the supply of hot air entering the cock-

pit. In some installations a conductor tube continues forward and provides the hot air necessary for windshield defrosting. Ventilation is usually provided for by ventilation ports opening to the outside. Each outlet is equipped with controllable deflectors.

b. Another form of simple hot-air heating system takes air directly from the air outlet of the air cooler or coolant radiator, and by a duct system directs it to the cockpit of the airplane. The temperature of the air entering the cockpit is controlled by mixing cold air with the heated air. This type of system is found principally in single-place airplanes equipped with a liquid-cooled engine.

35. STEAM HEATING SYSTEMS. a. General. Heating systems depending upon steam as their source of heat consist of two separate and distinct sections: an air-duct section and a steam-generating section. The air-duct section supplies, controls, and distributes the air used for heating and ventilating. The steam-generating section serves to transfer the heat from the exhaust manifold to the incoming cold air. A system of this type is shown in figure 47.

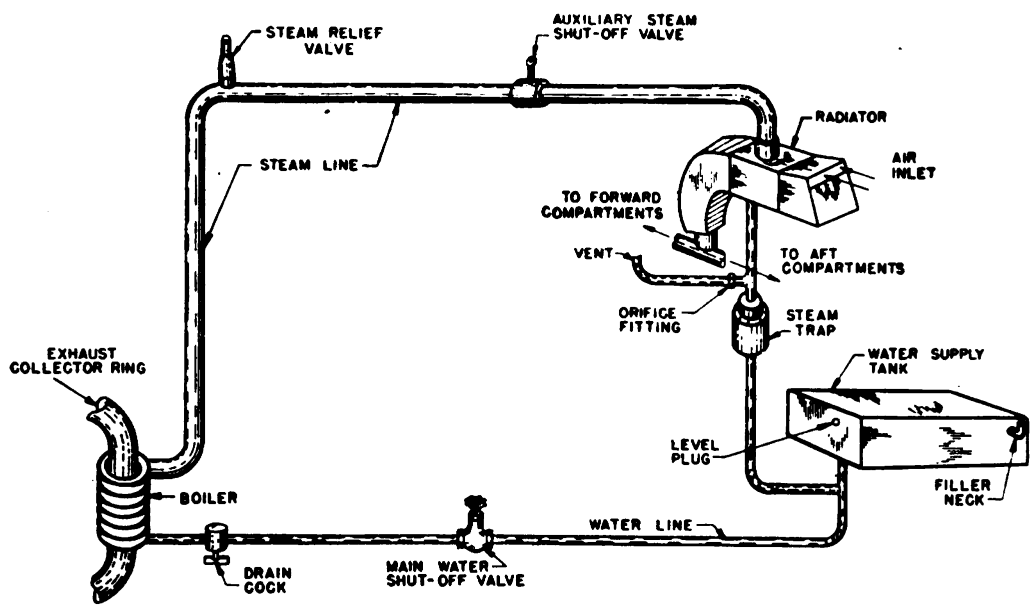


Figure 47. Steam heating system.

b. Air-duct section. The air-duct section is made up of the following parts:

(1) An air scoop, which opens forward into the air stream admitting outside air into the airplane.

(2) An induction duct, which is a cold-air duct that conducts the air from the scoop to the radiator. In some cases this includes a bypass duct around the radiator.

(3) A radiator, in which the air is heated by passing over steam-heated surfaces. (A more detailed description of this unit is included in (c) below.)
(4) The distributor ducts, which are warm-air ducts that conduct the heated air to the various compartments of the airplane.
(5) Air controls, which control the rate of flow of air in the various ducts. They may be of either the damper or the sliding-gate type. In general, a cold-air control is installed in the induction duct to regulate the supply of cold air to the system, and individual air controls are located in the separate distributor ducts to control or shut off the supply of hot air to the various compartments. When a bypass around the radiator is used, an additional control is usually incorporated to regulate the relative amounts of incoming air going through and bypassing the radiator.

c. Steam generating and distribution system. The steam generating system may be one of several types, each having a slightly different method of operation and control, but all depending on the same basic principles and having the same basic units. The steam-generating system is composed essentially of a water-supply tank, a water shut-off valve, a boiler, and a radiator.
(1) The water-supply tank or reservoir is a unit used to furnish the supply of water for the steam-generating system. It may be a sealed chamber designed to hold steam and water at pressures above atmospheric pressure or merely a container with a filler neck to hold water at atmospheric pressure. In some installations a gauge glass to show water level and a pressure gauge to show tank pressures are included with this unit. Reservoirs are equipped with fittings for connection to the other units used in the system. In some cases the reservoir has a drain cock. Reservoirs which do not have a sight gauge usually have a level plug.
(2) A water shut-off valve controls the amount of water passing into the boiler. This valve is normally used to control the temperature of the warm air by allowing more or less water to run into the boiler.
(3) The boiler is a unit used to generate steam by passing the exhaust gases from the engine over a number of seamless tubes or through a muff containing water. It is located in the engine exhaust system and in most cases forms a section of the exhaust collector ring. Because of its high melting point and heat-resisting properties, Inconel steel is used in the construction of this unit. In general, the unit consists of a circular tube casing containing a number of small seamless tubes manifolded internally at the top and bottom of the casing, so that there are only two external connections—a water inlet which is located at the bottom and a steam outlet at the top. In the muff type boiler the water is passed through a jacket around the exhaust collector ring. Water enters the jacket at the bottom of the boiler and steam goes out a fitting at the top. A condensate return from the steam duct to the water supply line may be internal or external to the boiler.

(4) The radiator is used to transfer the heat from the steam to the incoming cold air in the system. It is the one unit which is common to both the air-duct and the steam-generating systems. In general, radiators consist of a brass casing containing either a number of coiled copper tubes manifolded internally at the two ends of the unit, or a copper honeycomb. Fins of thin copper sheets run between the tubes to aid in the conduction of heat from the steam in the tubes to the incoming cold air passing through the casing. One end contains a fitting for connection to the steam duct from the boiler, while the other end may contain one or two fittings for connection to the water return system and the vent line.

(5) A steam safety valve is located either on the steam duct between the boiler and the radiator in a gravity-feed system or on the reservoir in a pressure system. The valve is a spring-loaded relief valve, which automatically limits the pressure in the system to a given value.

(6) An auxiliary steam shut-off valve is located between the safety valve and the radiator. It is controlled by a push-pull rod and is of the butterfly type. This valve should be used only in case the main water shut-off valve fails to function properly and allows the water to continue to run into the boiler after it is closed.

(7) Some steam heating systems include a water regulating valve to prevent steam from the radiator from entering the reservoir. This valve consists of a sealed cylinder which floats when surrounded by water, and seats over the outlet when surrounded by steam.

d. Operation. (1) Water is placed in the reservoir through the filler neck. A level cock on the side of the tank limits the height of the liquid. Gravity causes the water to flow out of the bottom of the reservoir into a tube leading into the boiler. The rate of flow of water to the boiler is controlled by the main water shut-off valve. The water enters the bottom of the boiler. The heat from the exhaust collector ring causes the water to reach its boiling point rapidly and become steam, which rises through the tubes in the boiler into the steam line leading to the radiator. A drain is sometimes provided to allow any water which condenses in the steam line to flow back into the water supply line. A spring-loaded safety relief valve in the steam line relieves the pressure when it exceeds a given value. An auxiliary steam shut-off valve is installed in the steam line to control the flow of steam if the water shut-off valve fails to function. The radiator is mounted directly above the water reservoir.

(2) Steam entering the radiator heats the manifolded tubes. Cold air, which is brought in from the outside by the air scoop, passes over the tubes and is heated. The hot air then passes out through hot-air ducts to the various compartments of the airplane. This transfer of heat to the cold air condenses the steam in the radiator, causing it to collect in the bottom of the radiator casing. This water passes from the bottom of the radiator through openings in the casing, through orifices in the return line, through the water regulating valve, and back into the reservoir. Any steam which

is not condensed in the radiator passes out of the airplane through the vent. A return line to the water reservoir from the vent is provided to take care of any steam which condenses in the vent line.

e. Inspection and maintenance. Steam heating systems are comparatively simple and require little maintenance. Periodic inspections are made to insure that all parts are securely attached. The air scoop is checked to see that it is securely mounted and clear of all obstructions in the form of debris and trash. The control linkage is inspected for proper connection and free operation. The amount of water in the boiler of the steam heating system is checked and added to if necessary. All parts of the system are checked for leaks, corrosion, and obstructions. A check is made to see that there is ample clearance between the air ducts and heater control and all other controls in the system.

36. GLYCOL HEATING SYSTEMS. a. General. In the glycol type of heating system, heat is transferred to the ventilating air from a glycol system. The system consists of two separate sections: an air-duct section and the glycol section.

b. Air-duct section. The air-duct section is essentially the same as the air-duct section described under steam heating systems.

c. Glycol section. Figure 48 shows the glycol section of this type of system. This section transfers heat from the engine exhaust stack to the incoming air. It consists of the following units:

(1) A supply tank to store reserve fluid. This tank is vented to the atmosphere and usually contains a stick gauge.

(2) An engine-driven pump to circulate the fluid. A vane type pump is usually used.

(3) A filter to remove impurities from the fluid.

(4) A relief valve to prevent the development of high pressure in the system during operation of the system in very cold weather.

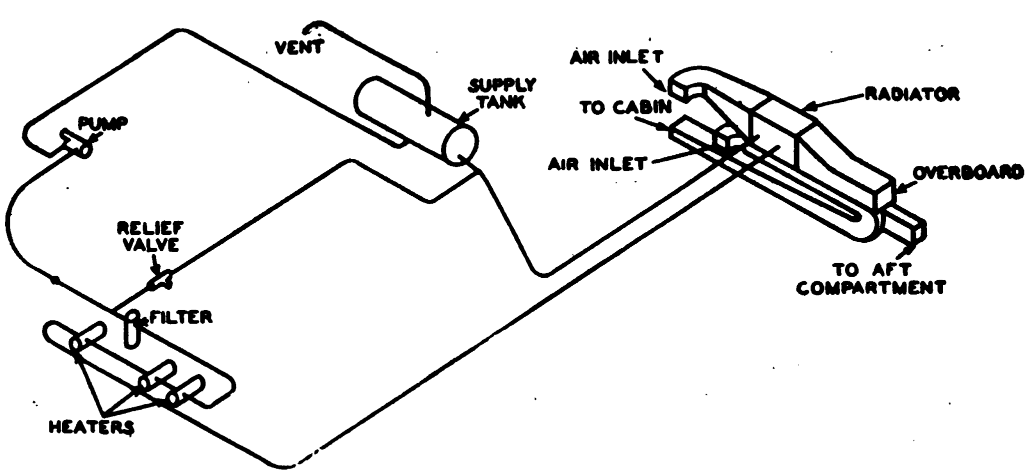


Figure 48. Glycol heating system.

(5) Heaters mounted on the engine exhaust stack to transfer heat from the exhaust gases to the glycol.
(6) A radiator in which heat is transferred from the glycol to the ventilating air.

d. Operation. (1) The system is filled with the *correct* glycol solution. (Prestone is not to be substituted.) This solution flows from the supply tank to the pump. The pump circulates the glycol through the filter, the heaters, the radiator, and back to the supply tank. This circulation is continuous as long as the engine is running. As the glycol passes through the heaters it absorbs heat from the exhaust gases. As the hot glycol passes through the tubular cooling radiator it is cooled, and the incoming cold air is warmed. This warm air may be directed through the air-duct system for heating the airplane, or it may be directed overboard by a damper. The position of the damper is controlled from the cabin.
(2) When the system is put into operation in very cold weather, the glycol will not pass through the filter. When pressure in the line to the filter reaches the kick-out pressure of the relief valve, this valve opens and by-passes the output of the pump to the supply tank until the glycol heats enough to pass through the filter. The valve then closes and the system operates as described.

e. Inspection and maintenance. (1) Check the fluid level in the supply tank on the preflight inspection. Fill to the "Full" mark on the stick gauge with the specified fluid. Check the system for leaks, check the condition of units and lines, and inspect the ventilators for operation on the 25-hour inspection. The filter must be cleaned at least once each 75 hours. The system should be drained, flushed, and filled with fresh fluid according to existing instructions.
(2) If the heaters are damaged, they should be replaced. *Do not attempt to repair or patch them.*
(3) In systems which have three heaters, it is usually necessary to remove one of the heaters in warm weather to allow for sufficient cooling of the glycol. If in doubt, check the temperature of the glycol in the supply tank during ground runs, and if the temperature reaches 177° C. remove one of the heaters. Replace the heater with the cover plate supplied for this purpose. The heater is stowed in the luggage compartment.

37. COMBUSTION HEATERS. a. General. Each heater consists of a burner assembly, a fuel-air system and an electrical system containing one or more thermo-snap switches. Some heaters include a fan assembly. (See fig. 49.) Heat is produced by burning a fuel-air mixture in a chamber and conducting the hot gases through an oven. Air blown over the heated oven by the fan or forced over the oven by ram air is warmed. This warm air is used to heat cockpits and cabins, defrost windshields, etc.

b. Burner assembly. It is in this unit that heat is produced by burning

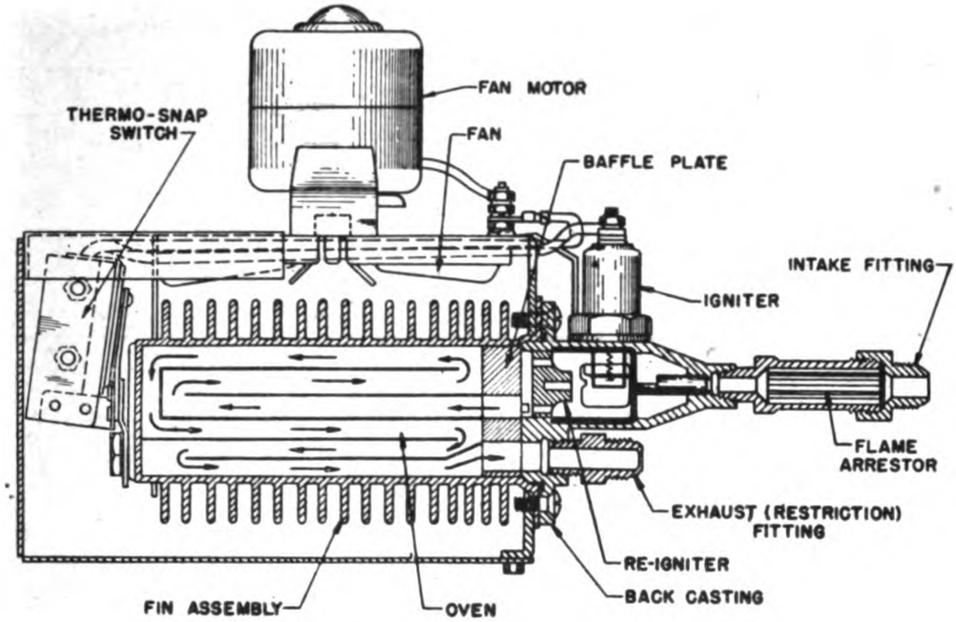


Figure 49. Combustion heater.

a fuel-air mixture from the airplane engine induction system. It consists essentially of the following parts:

(1) An inlet nipple containing a flame arrestor. This prevents flames from burning back into the fuel line.

(2) A combustion chamber containing an igniter, a reigniter, and a baffle plate. The igniter starts the fuel-air mixture burning. The reigniter is heated by the burning gases. It will reignite the fuel-air mixture if the flow is interrupted for a short time. The baffle plate prevents flame from entering the oven.

(3) An oven and fin assembly. The oven, which contains continuous passages, is mounted inside the fin assembly.

(4) An outlet nipple containing a restriction fitting.

c. Fan assembly. This assembly consists of a fan and an electric motor. The fan blows cold air over the oven and fin assembly. The air absorbs heat and is blown out of the bottom of the heater.

d. Fuel-air system. The fuel-air mixture is piped to the heater from the airplane engine induction system or from a gasoline engine driven heater supercharger. A manually operated valve or a solenoid valve may be used to control the flow of fuel-air mixture to the heater. If a manually operated valve is used, it must be opened when the heater switch is turned on and closed before the switch is turned off. If a solenoid valve is used, it opens automatically when the heater switch is turned on and closes when the switch is turned off.

e. Electrical system. Wiring diagrams of electrical systems of heaters are shown in figure 50. Current for the heater is obtained by tapping the

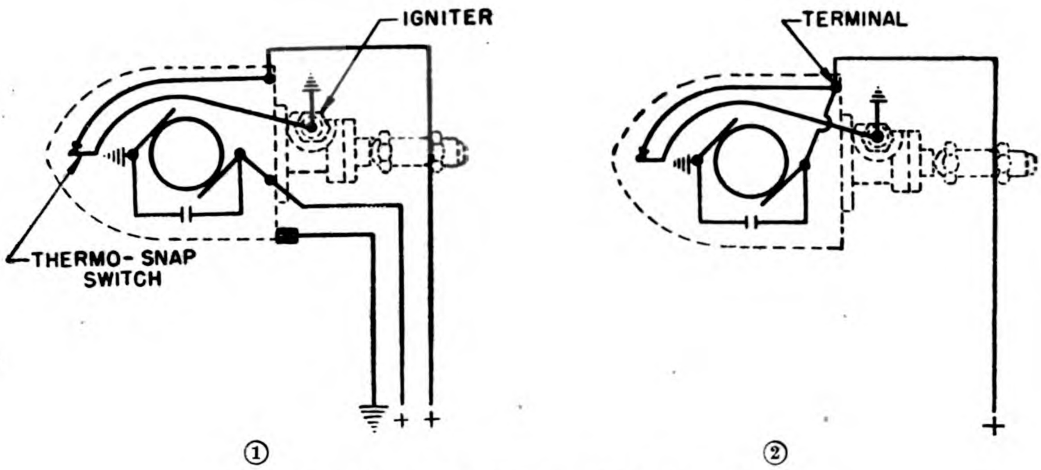


Figure 50. Wiring diagrams—combustion heaters.

electrical system of the airplane. Either one or two lead wires into the heater may be provided. If two lead wires are provided (fig. 50①), one is connected to the fan motor, and the other is connected to a terminal. A lead from this terminal is connected to one side of the thermo-snap switch. The other side of this switch is connected to the igniter. If one lead into the heater is used (fig. 50②), it is connected to the terminal. Leads from the terminal are connected to the thermo-snap switch and the fan motor. A typical wiring diagram for a six-heater installation is shown in figure 51.

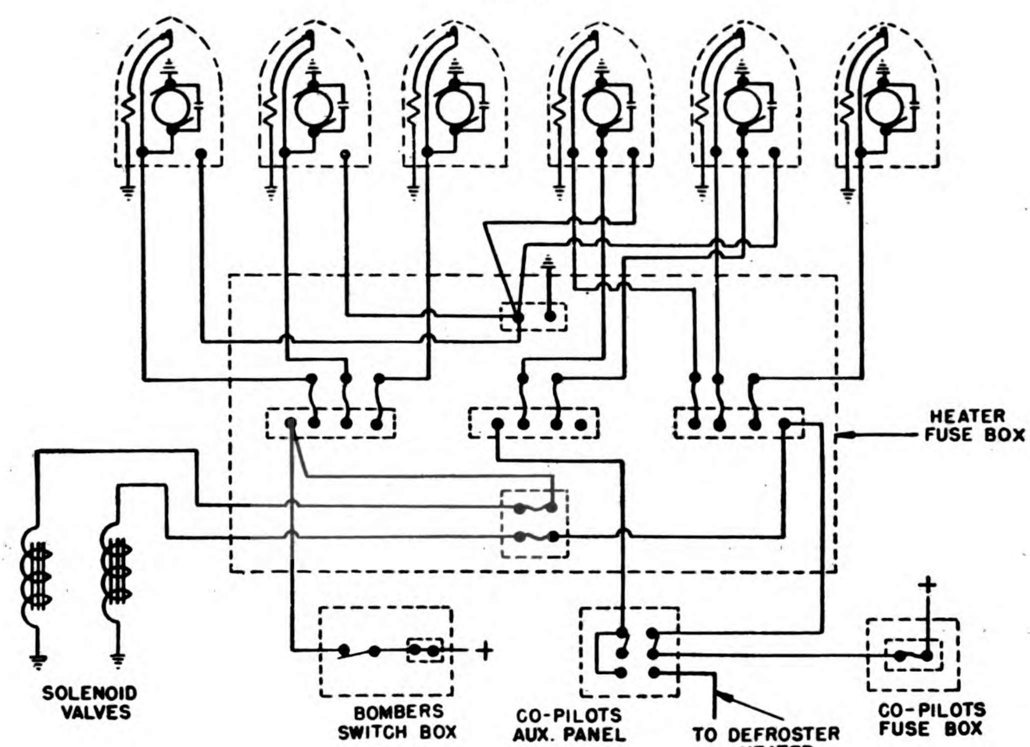


Figure 51. Typical wiring diagram—six-heater installation.

f. Operation. When the heater switch is turned on, current flows to the solenoid valve (if used) and opens it. This allows fuel-air mixture from the airplane engine induction system to flow into the combustion chamber of the heater. At the same time current flows directly to the fan motor and to the igniter through the closed thermo-snap switch. The igniter becomes hot enough to ignite the fuel-air mixture. The burning gases pass through the holes in the igniter and strike the baffle plate where combustion is completed. The hot gases then pass through the center hole in the baffle plate into the oven. The gases flow through the oven as shown by the arrows in figure 50 and out the restriction fitting. When the oven is heated, the thermo-snap switch opens and interrupts the flow of current to the igniter.

g. Inspection and maintenance. (1) At each 25-hour inspection the heater casting and oven assembly should be inspected for carbon or lead deposits, and if necessary these parts should be cleaned. If field checks indicate that it is unnecessary to clean these units every 25 hours, the period between inspections may be increased.

(2) The igniter is checked at the 50-hour inspection by attaching a voltmeter to the igniter terminal and a satisfactory ground. If the igniter is drawing the proper current, the voltmeter should indicate a voltage of at least 22 volts. The igniter casting should become warm under these conditions. If it does not, the igniter should be replaced. If, in testing with a voltmeter, no voltage is indicated, the thermo-snap switch is open and must be either adjusted or replaced.

(3) If inspection of the heater indicates that it is in need of an overhaul, it should be removed from the airplane and the necessary cleaning and replacements should be made.

(4) Inspect the fan blades for clearance and all electrical and plumbing connections for tightness.

(5) The back casting and oven should be removed and cleaned every 100 hours. Clean the inside of the back casting with emery paper and blow out with compressed air. Clean the oven by inserting a narrow wire brush in each passage and blowing out with compressed air.

38. VENTILATION. Very often the air ducts of the heating system are used to furnish ventilation of the various sections of the airplane. Some airplanes have a ventilating system which is independent of the heating equipment. In an independent system, an opening in the leading edge of the wing or some other structure provides an air intake. Ducts ending in controllable openings lead from this intake to the various parts of the airplane.

SECTION IX
ELECTRICALLY HEATED CLOTHING

39. GENERAL. Electrically heated clothing consists of suit, shoes, and gloves. Resistance wire is sewed into the material of which the clothing is made. A short length of cord and a plug are attached to a junction box in the suit for connecting the heating elements to the airplane electrical system. The suit has receptacles at the ankles and wrists for plugging in the shoe and glove connections. In some suits, the shoes and gloves are connected in series. In others, the two shoes are in one circuit and the two gloves are in another.

40. TYPES. Electrically heated clothing is provided for use with a 24-volt system.

41. USE. a. General. (1) The electrically heated suit is worn over undergarments to prevent possible burns. Any type of flying suit may be worn over it. Lightweight socks should be worn under the heated shoes. Suitable flying shoes should be worn over them.

(2) The Q–1–A rheostat has two sockets, the left socket for the electrically heated suit and the right socket for the signal lamp.

b. Operation. To put the heating elements of the clothing into operation, the following procedure should be followed:

(1) Plug the electrical connections on the shoes and gloves into the receptacles at the ankles and wrists. Care should be taken to see that each shoe and glove is connected. If one of these units is not connected, none of them will heat.

(2) Draw the plug attached to the suit through the side pocket vent of the regular flying suit and connect it to the female receptacle of the 6-foot lead cord.

(3) Connect the twist lock plug on the other end of this cord to the rheostat, one of which is located at each crew station on airplanes wired for the use of heated suits. Clockwise turning locks the plug in the rheostat.

(4) Adjust the rheostat to furnish the minimum energy input necessary for comfort. The clothing should not be hot enough to cause the user to perspire.

42. INSPECTION AND MAINTENANCE. a. Inspection. External connections and wiring should be checked periodically for looseness and corrosion. Operation of the clothing and rheostat should be checked before each flight on which it is to be used.

b. Maintenance. The suit may be washed or dry cleaned without affecting the electrical circuit. The shoes may be washed. Testing and repair of the clothing is done by subdepots or depots.

SECTION X
AUXILIARY POWER UNITS

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43. GENERAL. a. Purpose. Auxiliary power units installed in airplanes have the following functions:

(1) To recharge the batteries while the airplane is on the ground.

(2) To furnish electrical energy during flight if the main generator system should fail.

(3) To supplement the batteries during starting.

(4) The auxiliary power unit will be used for testing and checking of all electrical units and radio apparatus when the airplane is on the ground or when the generator system is not operating.

b. Types. Auxiliary power units have been designed for use with both 12- and 24-volt airplane electrical systems. A typical unit, the C–10 (Homelite HRU–28) will be discussed in this section.

44. DESCRIPTION. This unit consists of a gasoline engine assembly, an electrical power system, and a mounting base. It is designed to deliver 28.5 volts direct current. This voltage is controlled by a regulator mounted on the generator.

a. Engine assembly. The engine assembly consists of a single-cylinder, two-cycle, air-cooled engine, an automatic governor, an air cleaner, and a fuel tank. The engine ignition system includes a high-tension, flywheel type magneto. The engine is directly connected to the generator.

b. Electrical system. This system consists of a 2,000-watt generator and a control box which contains a reverse current cut-out, starting switch, voltmeter, equalizer switch, outlet receptacle, and radio filters.

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c. Mounting base. The base consists of a channel-iron frame to which four shock-absorbing springs are attached. Four thumbscrews are provided for attaching the mounting base to the supplementary base in the airplane.

45. OPERATION. a. Before starting. Thoroughly mix ½ pint of the correct grade oil with each gallon of gasoline and fill the fuel container. Specification AN–VV–O–446*a*, grade 1065 oil, and specification AN–F–26, grade 91, or AN–VV–F–781, grade 100, or AN–F–28, grade 130 fuel, are satisfactory. To measure the oil, fill the container cap four times. Be sure the ground wire clip is attached to the container before filling.

b. Starting. (1) Turn the shut-off valve on top of the fuel container to ON. See that the equalizer switch (on the control box under the generator) is in the OFF position unless the airplane engines are running. Pull the button on the priming-pump plunger (on top of the air cleaner) all the way up and release two or three times. In cold weather, more priming may be necessary. Depress the starting switch on the control box. Release the switch as soon as the engine starts. If the engine does not start, it may be flooded. To remedy this, open the drain cock on the crankcase and hold the starter switch down for a few seconds. Then close the drain cock and depress the starting switch.

(2) If the batteries are dead, the engine may be started manually with the starting rope. Wind the rope around the starting plate in the direction of the arrow. Brace one hand on the unit and give a hard, quick pull. Repeat if necessary until the engine starts.

c. Stopping. (1) To stop the engine, turn the shut-off valve on top of the container to OFF. The engine will run approximately ½ minute before stopping. When the airplane is in flight but its power plant is not running, the fuel shut-off valve must be closed.

(2) For emergency stopping, or if the engine is to be restarted soon, press the red button (near the starter plate) and hold down firmly until the engine stops.

46. INSPECTION AND MAINTENANCE. The following inspections should be made and maintenance performed at the periods specified in Technical Orders:

a. Check fuel level and refill container if necessary.

b. Check spark plug for fouling and gap clearance.

c. Inspect connections for tightness and wiring for faulty insulation.

d. Clean air filter.

e. Check magneto breaker points for proper gap.

f. Check the generator brushes. Replace if worn to less than the minimum allowable length.

g. Check the voltage regulator and reverse current relay.

47. TROUBLES AND REMEDIES. The following chart lists common troubles with this unit, their possible causes, and the remedies for them:

Trouble	Possible Causes	Remedy
Unit fails to start.	Fuel shut off.	Turn shut-off valve on fuel tank to ON.
	Fuel lines clogged.	Clean lines.
	Spark plug fouled.	Remove, clean, reinstall.
	Spark-plug points out of adjustment.	Regap.
	Spark-plug points badly burned.	Replace plug.
	Magneto high-tension lead grounded or broken.	Repair ground or replace lead.
	Magneto contact points out of adjustment.	Adjust points.
	Magneto contact points pitted.	Hone or replace points.
	Defective coil.	Replace coil.
	Battery supply is not connected.	Connect batteries.
	Primer not operating.	Check and repair if necessary.
	Engine flooded.	Open drain cock on crankcase and drain excess gasoline by turning over engine a few times.
Arcing at brushes.	Dirty commutator.	Clean commutator.
	Worn-out brushes.	Replace brushes.
	Brushes stuck in holders.	Loosen and clean brushes.
	Short circuit in system.	Check connections. Rewire if necessary.
	Brushes reversed in holders.	Reverse brushes.
Engine runs but unit fails to put out voltage or current.	Broken connections.	Check wiring; rewire where necessary.
	Voltage regulator not installed.	Install voltage regulator.
	Voltage regulator out of adjustment.	Adjust voltage regulator.
	Reverse-current relay not closing.	Repair or replace reverse-current relay.
	Shorted or open field or armature of generator.	Replace unit if impossible or impractical to repair.
	Brushes not seated or dirty commutator.	Clean commutator and replace brushes if they show excessive wear.
	Engine speed slow.	Check engine governor and reset when necessary.

47. TROUBLES AND REMEDIES—Continued.

Trouble	Possible Causes	Remedy
Engine runs hot but generator functions correctly.	Load too heavy.	Voltage-regulator adjustment should be lowered.
	Not enough oil in fuel mixture.	Add oil to fuel and mix thoroughly.
	Tight bearings.	Increase oil in fuel and attempt to "run in."
	Air-blast fan damaged.	Replace fan.
Noisy radio reception.	Defective filters in control box.	Replace filters.
	Loose connections.	Tighten.
	Loose or dirty spark-plug shielding assembly.	Tighten or clean.
	Excessively dirty commutator.	Clean.

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